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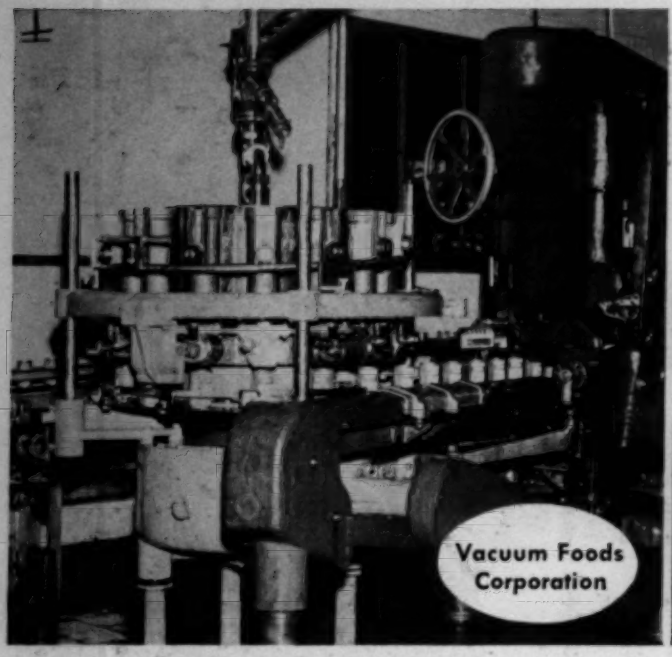

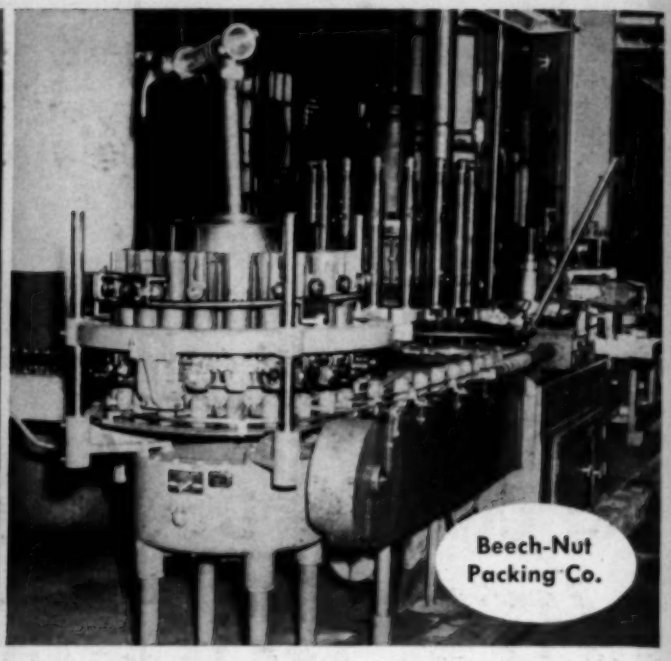

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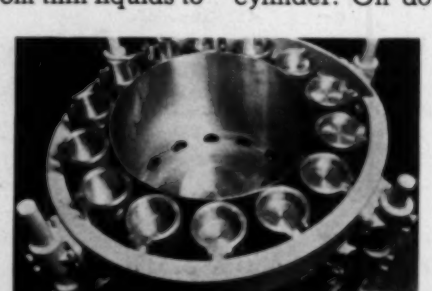

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Food—Ally of Democracy

During the recent period of great social and economic disturbance, many of us have heard, read, and possibly expressed opinions of a pessimistic pattern as to how the trend toward regimentation is destroying the virile characteristics which have brought greatness to the American nation. The passion for personal security, which seems to be responsible for the desire for regimentation, does indeed tend to destroy initiative but we too often overlook the fact that the virility which is responsible for initiative and which can convert initiative into accomplishment is not easily destroyed. In fact, there is a very real factor which is generally obscured when the thinking back of the extremely pessimistic opinions is less profound than it should be.

We should not, of course, allow polyanna thinking to obscure the actual existence of a probability that individualistic effort is being discouraged by socialistic trends; at the same time we need not blind ourselves to the less somber aspects of the situation existing in a face to face encounter with the problem of how best to oppose subversive influences.

The course which is usually advocated for avoiding the loss of opportunities for self advancement includes three requirements, among things of temporal nature, which must be provided. These are (1) political stability, (2) technical skill and knowledge, (3) supply of capital. These are indeed necessary, but there is a fourth requirement which is mentioned too infrequently —the requirement of individual inclination. Even when the existence of this requirement is recognized, seldom is the basic foundation of individual inclination given due consideration.

What is the basic foundation of individual inclination?

Any system which aims to regulate the lives of people in every detail must first attain subjugation of the intellects of the people. This can be done only by keeping the standard of living low—particularly that part which is most directly related to bodily sustenance, namely, food supply. When the body is poorly nourished, the intellect becomes passive; on this condition, the maintenance of tyrannical rule depends.

Observant persons marvel at how one's physical condition affects his mental outlook. Totalitarian rulers are usually aware of this correlation in human nature; they realize that any marked improvement in standards of living of their subjects would mark the beginning of their downfall. Improvement in physical condition brought on by improved bodily nourishment inevitably stimulates the mental processes; stimulated mental processes produce individualistic thinking and dissatisfaction with restrictions to personal liberty and freedom.

The passive mood is essential to the sustenance of communism. Passivism on a broad scale can be maintained only when subjects are improperly nourished. As long as they are improperly nourished, they cannot be efficient. If proper nourishment is provided for them, they will spontaneously move out of their passive mood and will overthrow communism. Proper nourishment makes for clear thinking, either in the educated or the non-educated person. That is communism's dilemma, and democracy's assurance.

The same principle applies on a higher level in a nation of free people. Regardless of the strength of political or other influence which feeds on the passion of certain classes for the elusive will-o'-the-wisp often called "security," the well-fed individual, in general, refuses to align himself with the "gimme" element; he will not be denied the joy of accomplishment nor the satisfaction of following his natural desire to play an active part in producing the means to elevate his standard of living and that of his fellow citizens.

This statement is not intended to imply that everyone who is properly fed always wants to do the right thing. If does signify, however, that, in general, the capacity of individuals to discern the difference between sound and unsound theory and practice is directly proportional to the quality of bodily nourishment they enjoy, and it denotes the belief that no people as well fed as the American people can be led into acceptance of communism, or even into acceptance of pink doctrines which approach communist ideology.

The entire western world was inspired recently by the fact that little Finland, located on the edge of the Soviet Union and just a few hundred miles from the Soviet capital, had the spirit and the ability to hold a free and democratic election. The western world was further inspired by the results of the election and was filled with admiration for the courage and fortitude of the Finnish people, which were manifested by those results. One will probably never find a better illustration of the working of the principle we have just expounded. Whence comes the Finns' courage and their ability to distinguish the true from the false channels of accomplishment and progress? They come not from education, not from propaganda, but from nourishing food. If the Germans, for a period of a few years, could be as well-fed as the Finns, probably we should no longer have to worry about the power of the insidious slogan, "Deutschland über Alles." This would not be because the desires of the German people would have become satiated but because the people would be able to appreciate the folly of the slogan.

The existing confusion of opinion as to whether or not a propaganda campaign directed to those behind the iron curtain is worth while is certainly explainable, in part at least, by the fact that many passive minds which a campaign is intended to influence are passive because it is impossible for them to be otherwise. No amount of propaganda alone could stir them into an active state. Most of those, either behind the iron curtain or elsewhere, who have chosen a mood of surrender in place of a mood of resistance, have done so not because of propaganda but because their low standard of living has removed from them their normal inclination to resist regimentation and to be self reliant.

For lasting results, a propaganda campaign must be accompanied by something to sustain the results. Proper food is the only sure sustaining factor. Propaganda in the form of education in proper eating and in the means to put this education into use (means to provide proper food) offers the promise of the greatest effectiveness in the cause of democracy.

The normal inclination of the healthy human being

to produce something to benefit himself and his fellow citizens must be accompanied by an opportunity for him to produce what he is capable of producing. It seems to be normal for the average person to believe that he individually is producing more than he is being paid for. This tendency is not to be deplored provided it does not destroy the patience which makes one satisfied to bide his time for better remuneration. It is, in fact, desirable for the individual to accept the situation as natural that he should habitually deliver more to his employer than he is paid for. This feeling exists in persons in all walks of life—those in the role of management as well as those in the role of labor and in other categories. Oftentimes, however, either because he believes that the average person is not capable of accepting an unbiased viewpoint or for some purely selfish reason, a person feels also that it is his duty to introduce a biased viewpoint into any discussion of equitable returns for all. This course always results in ambiguous arguments which quickly reveal insincerity.

Regimentation of members by labor unions on the basis of seniority cannot destroy the inclination of a normal, healthy, individual to exert unusual effort to bring about self advancement. Collective bargaining will never succeed if the position taken by labor fails to recognize the fact that this inclination cannot be suppressed in the individual who has the energy and initiative which accompany a high level of physical well-being. Any attempt to suppress such inclinations is an attempt to strike down the most potent sustaining force of democracy.

Although individual ardor for accomplishment is a force which cannot be obliterated in a nation of well nourished people, we cannot afford to let a realization of the existence of the force lead us into complacency. Food alone cannot do the job although it can do a tremendously large portion of it. Another important factor rests in providing opportunities to individuals to follow their inclinations to produce things for society. To provide an incentive to the individual to follow this inclination is the prime function of democracy. To provide an opportunity to the individual is the prime function of industry.

Too often, arguments supporting capitalism's side of a question must be so reserved that they cannot be made convincing; discussion of too many pertinent factors must be excluded. Those who support capitalism in discussions of specific questions often refuse to take a clear-cut and decisive stand on a matter which should be upheld to the limit without equivocation. An unequivocal stand is not taken because such a stand would require the airing of some factor which the arguer does not wish to defend. The course which must be followed sooner or later if capitalism is to survive is first to eliminate practices which are ethically unsound; then to go "all out" in support of the fundamental tenets of capitalism which reside in the principle of reward for individual initiative and effort.

Providing opportunity for the individual in proportion to his ability to utilize the opportunity must supercede all other objectives in industrial, economic, or technological planning. It must supersede the necessity for a $100,000-a-year executive to prove that he is a better man than a $50,000-a-year executive and thus protect his position as a higher paid person. It must also supercede the necessity for a labor leader to justify his salary by obtaining advantages for his union which may be entirely unjustified by conditions.

Very seldom, no doubt, is a collective bargaining agreement in industry, or even a court decision, absolutely just and equitable. All processes of justice, however, in a country of high living standards would result in the greatest possible general benefit if they were conducted in full sincerity by all participants. One does not have to be a college graduate to be able to distinguish between a fair situation and an unfair situation when the pertinent facts are available. In fact, a satisfactory physical state of being probably means more in providing an individual with this power of discernment than does a college education. In other words, as a class, the non-college trained person whose state of health over a substantial period of time has been such as to cause him to be mentally active probably renders decisions which are superior ethically to those of the college graduate whose state of health over a substantial period of time has been such as to cause him to be mentally depressed and passive. Here again is a principle which may be said to apply to persons in executive, labor, and other categories alike. There is probably no group of well nourished people in the United States, the majority of whom would not concur in the well known principle that, for efficiency, industrial management must be confined to a comparatively few individuals of special qualifications and that these individuals are entitled to a high rate of compensation in consideration of the exceptional (and very important) service which they render to the industrial enterprises and to society.

A suggested formula, therefore, for ensuring the preservation of democracy in the United States, or throughout the world, is (1) produce in the people an active mental state by making it possible for them to have nourishing food in adequate quantity, (2) provide situations in which opportunities will be offered to individuals to produce according to their normal inclinations and capacities which always accompany a high level of physical well-being.

With this formula in effect, political ballyhoo intended to appeal to temporizers and egotists—even promises of pensions at fifty—can have very limited effect; the average person is not attracted by it.

On a world-wide scale, let us keep the horse in front of the wagon. For telling effect, the first assistance to backward people must be in the form of improved food; this must precede even moral uplift. When this first assistance has been rendered, the groundwork has been provided for moral, technological, and economic advancement through the efforts of the people themselves. If this logical first step is not taken first, other attempts to improve the condition of the people can be of little avail.

Fellow Food Technologists, behold our field for service! Our best effort in counteracting the insidious effects of hand-out philosophy, which are so feared by many, is to stick to our jobs of providing more and better food.

C. Olin Ball.

Film Yeasts on Commercial Cucumber Brines[a, b]

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A study of the types of film yeasts found on commercial cucumber brines, ranging in salt content from 5 to 19 percent salt by weight is presented. The cultural and biochemical properties for the species placed in 4 genera are given.

The surface of cucumber brines sheltered from direct sunlight develops luxuriant films attributed to film-forming yeasts. The matter of film yeast control has been a controversial question in the industry. Some operators prefer to remove the film by skimming; some to keep the brine surface stirred to discourage film formation; others to leave the film growth undisturbed. Before adequate control measures can be considered, more information on the identity of the common types occurring on cucumber brines, and their biochemical properties, is necessary.

The present investigation was undertaken to obtain some of the specific information needed on the principal types of these film-forming yeasts. The experiments were conducted under conditions typical of the industry in several sections of the United States.

Recently, Etchells and Bell *(3)* have stressed the need for a clearcut distinction to be made between the surface yeasts and subsurface yeasts in relation to cucumber brines, a point frequently confused in the literature. These authors obtained and identified 1,424 isolates of the latter type from 42 actively fermenting brines. The cultures were reduced to the following six genera in the order of frequency of isolation: *Torulopsis,* 721 isolates; *Brettanomyces,* 588; *Zygosaccharomyces,* 59; *Hansenula,* 49; *Torulaspora,* 6; and *Kloeckera,* 1. Species of film yeasts such as found by Mrak and Bonar *(7)* on brined foods were not obtained.

Source of Brines

In the present work, 47 cultures from commercial brines were collected during the 1947 and 1948 brining seasons. These cultures came from the surface films of brines ranging in salt content from 5 to 19 percent salt by weight and represented 40 commercial vat brines from 12 brining stations in the following geographical areas: North Carolina, 14 vats; Wisconsin, 12; Indiana, 6; Georgia, 5; and Michigan, 3. The origin and generic classification of yeasts on these brines are shown in Table 1.

An additional group of 14 isolates of *Endomycopsis* were obtained from cucumbers brined under laboratory conditions at 5 to 6 percent salt.

Previous Investigations

Mrak and Bonar *(7)* investigated 28 cultures isolated from the surface films of 27 samples of various brined and pickled products (dill pickles, cucumber salt-stock, Zucca melon, green olives, Sicilian olives, dill weed, cauliflower, and ham). They found film yeasts that belonged to species of three genera: *Debaryomyces,* 16 isolates; *Pichia,* 9; *Mycoderma,* 3. The *Debaryomyces* were found to be very salt-tolerant and predominated on brines of 15 percent and above. The other two genera were found on the brines ranging from 4 to 15 percent. Of particular interest to the present study is the finding of these workers that *Debaryomyces* was responsible for the films on all 7 samples of salt-stock cucumbers they examined. Further, of the 7 isolates they obtained from the films on 7 samples of dill pickles, 5 were placed as *Pichia* and 2 as *Mycoderma.*

Graham and Hastings *(5)* isolated 6 cultures of film-forming yeasts from the surface of rennet brines; all were placed in two species of *Debaryomyces.* Diddens and Lodder *(2)* listed salt pickles as the source of 5 cultures of *Candida krusei* but did not mention whether they came from films on the brine.

Review articles on yeasts appearing in 1941 *(6),* 1947 *(9),* and 1948 *(8)* list no additional genera occurring as films on brined or salted vegetables other than those that have been mentioned. The earlier literature on film-forming yeasts on brines, up to 1939, dealt chiefly with the occurrence of the genus *Mycoderma.* This has been adequately reviewed by Mrak and Bonar *(7)* as well as information on the salt-tolerance of yeasts in general.

Procedure

The cultures were taken directly from surface films on the brines and streaked onto previously poured plates of acidified, glucose agar *(4)* containing 6 to 8 percent salt by weight. Well-isolated colonies were then restreaked on the same medium for purification. The taxonomic methods employed and classification systems used were essentially those outlined by the Dutch workers *(1, 2, 10).* Certain recently described *(3)* modifications and additions to their techniques were included. For salt tolerance tests, a liquid medium was used consisting of cucumber brine fortified by the addition of glucose and ethyl alcohol in 1.0 percent amounts. The salt concentration of the brine was adjusted to cover a range from 5 to 20 percent by weight. To facilitate comparison of film formation by different yeasts, petri dishes with the bottoms divided into 3 and 4 sections were used (see Figure 1).

Genera Found

The 47 cultures were placed in the following genera: *Debaryomyces,* 22 isolates; *Endomycopsis,* 12; *Zygosaccharomyces,* 9; and, *Candida,* 4. An additional 14 isolates of *Endomycopsis* were obtained from a like number of films on cucumbers brined under laboratory conditions and were considered a different variety than those found on commercial brines. Yeasts belonging to

[a] Agricultural Chemical Research Division Contribution No. 247.

[b] This study was carried out under a cooperative project with the Department of Horticulture of the North Carolina Agricultural Experiment Station.

TABLE 1

Origin and Generic Classification of 47 Film-Forming Yeasts Occurring on 40 Commercial Cucumber Brines and Obtained from 12 Brining Stations Located in Five States

State	Brining Stations and Individual Vat Films Sampled		Age of Vat Brines at Sampling	Cultures Obtained from Films		Chemical Examination of Brines		
				Code	Genera[c]	Salt Conc.	Acidity as Lactic	pH
	Sta.	*Film No.*	*days*			*percent*	*percent*	
North Carolina (4 Brining Stations; 20 Isolates)	A	1	5	FY-24	Endomycopsis	6	....	....
		2	7	29	Endomycopsis	9	....	....
		3	13	25	Endomycopsis	13	....	....
		4	13	26	Endomycopsis	13	....	....
		5	13	27	Endomycopsis	13	....	....
		6	15	30	Endomycopsis	14	....	....
		7	20	28	Endomycopsis	15	....	....
	B	8[d]	12	Y-470	Endomycopsis	13	0.25	4.3
			12	474	Endomycopsis	13	0.25	4.3
			12	475	Endomycopsis	13	0.25	4.3
			18	FY-15	Endomycopsis	15	0.32	3.7
			22	16	Endomycopsis	15	0.30	3.8
			22	16R	Debaryomyces	15	0.30	3.8
	C	9[e]	12	FY-17	Candida	5	0.70	3.4
			12	18	Candida	5		
		10[e]	14	19	Candida	5	0.70	3.4
			14	20	Candida	5		
	D	11	20	FY-21	Debaryomyces	15	....	....
		12	20	22	Debaryomyces	15	....	....
		13	20	23	Debaryomyces	15	....	....
Wisconsin (4 Brining Stations; 12 Isolates)	A	14	35	NFY-21	Debaryomyces	11	0.74	....
		15	63	10	Debaryomyces	12	0.72	3.4
		16	72	24	Debaryomyces	13	0.70	3.4
		17	80	25	Debaryomyces	12	0.88	3.5
		18	1-year	22	Debaryomyces	16	0.55	3.6
	B	19	48	NFY-19	Debaryomyces	15	0.58	3.4
		20	69	3	Debaryomyces	14	0.71	3.5
		21	76	20	Debaryomyces	14	0.75	3.4
		22	92	1	Zygosaccharomyces	15	0.70	3.5
	C	23	85	NFY-13	Debaryomyces	13	0.94	3.2
		24	99	12	Debaryomyces	13	0.82	3.3
	D	25	67	NFY-26	Zygosaccharomyces	19	0.35	3.6
Indiana (2 Brining Stations; 6 Isolates)	A	26	54	NFY-23	Zygosaccharomyces	16	0.59	....
		27	62	7B	Zygosaccharomyces	13	0.85	3.7
		28	68	9	Zygosaccharomyces	15	0.54	3.8
		29	83	6	Zygosaccharomyces	15	0.74	3.7
		30	1-year	8	Zygosaccharomyces	16	0.46	3.9
	B	31	58	NFY-18	Debaryomyces	13	0.64	3.5
Michigan (1 Brining Station; 4 Isolates)	A	32	39	NFY-15	Debaryomyces	12	0.50	....
		33	50	14	Debaryomyces	13	0.82	3.6
		34	72	16	Zygosaccharomyces	13	0.72	3.5
		35	72	16B	Zygosaccharomyces	13	0.72	3.5
Georgia (1 Brining Station; 5 Isolates)	A	36	39	FY-33	Debaryomyces	12	....	....
		37	39	36	Debaryomyces	12	....	....
		38	39	37	Debaryomyces	12	....	....
		39	36	34	Debaryomyces	12	....	....
		40	36	35	Debaryomyces	12	....	....

[c] Does not include 14 isolates of *Endomycopsis* from films on 14 one-gallon lots of salt-stock cucumbers brined under laboratory conditions at 5-6 percent salt concentration.
[d] Six cultures isolated from film at 3 different time intervals.
[e] Two cultures isolated from film.

TABLE 2

Distribution of Film-Forming Yeasts Occurring on Cucumber Brines According to States

Yeast	Number of Isolates[f]	Distribution as to Brining Area:				
		North Carolina	Wisconsin	Indiana	Georgia	Michigan
Debaryomyces	22					
D. membranaefaciens var. *Hollandicus*		4	9	1	2	2
D. species (smooth)		0	1	0	3	0
Endomycopsis	26					
E. ohmeri		12	0	0	0	0
E. ohmeri var. *minor*[g]		14				
Zygosaccharomyces	9					
Z. halomembranis		0	2	5	0	2
Candida	4					
C. krusei		4	0	0	0	0

[f] The 61 isolates represent two groups; 47 came from films sampled from 40 commercial vat brines (N. C. 14 vats; Wisc. 12; Ind. 6; Ga. 5, and Mich. 3), and 14 came from films on 1-gal. lots of salt-stock brined under laboratory conditions at about 5-percent salt.
[g] The 14 isolates of this species came from laboratory source.

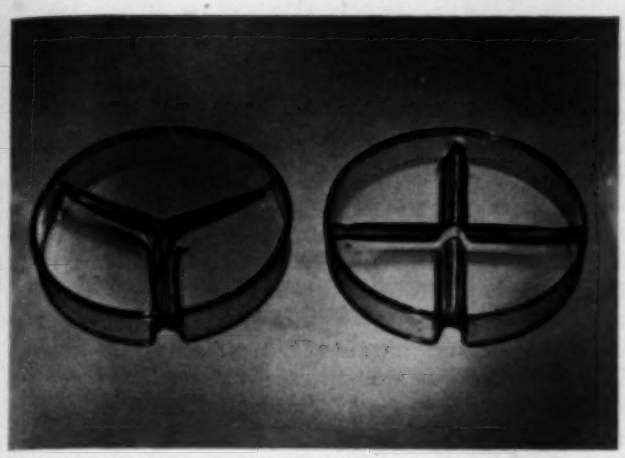


FIG. 1. Petri dish bottoms with 3 and 4 divisions used in comparison of film formation on brines of different salt concentration. These dishes have also been used for cultivation of giant colonies of yeasts on different solid media. The bottoms were made from regular pyrex dishes having a depth of 15 mm., a diam. of 90 mm., and take 100 mm. diam. cover. The divisions are approximately 8 to 10 mm. in height and were made by softening the bottoms with a flame and forming the divisions seen above.

the latter three genera have not, to our knowledge, been reported before in connection with film formation on salt-stock vegetable brines. Furthermore, yeasts belonging to the genus *Zygosaccharomyces* heretofore have not been considered associated with yeast genera capable of rapid and luxuriant film formation. This characteristic could easily be overlooked, because the *Zygosaccharomyces* from brine produce only a thin scum on liquid media containing certain of the sugars used in the fermentation tests. Also, no film is produced in alcohol in contrast to most yeasts classed as film-forming types. However, luxuriant films are rapidly produced in liquid media containing 5 to 20 percent salt.

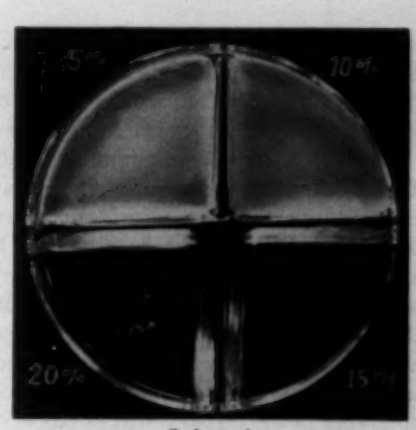
Distribution of Genera

Information on the distribution of the film yeasts, according to the five representative geographical brining areas, is shown in Table 2. Yeasts belonging to the genus *Debaryomyces* were most widespread. They were found in all five states and were also the most frequently isolated from the commercial brine films. The *Zygosaccharomyces* were found in all northern states.

The *Endomycopsis* and *Candida* were limited to brining areas in North Carolina. The *Endomycopsis* genus was isolated from brines with a rather wide range of salt concentration (Table 1) and it seems reasonable that this was not a deciding factor for limiting their distribution. The *Candida* came from the films of two vats of genuine dills having brines of about 5 percent strength. This points to a direct relationship between brine strength and the possibility of finding isolates of this species of *Candida*.

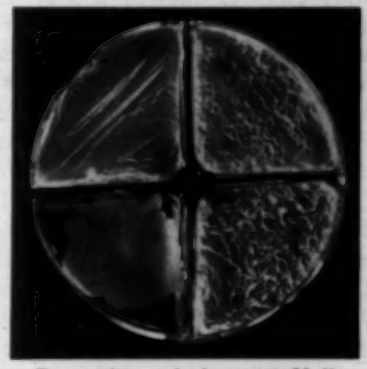
Salt Tolerance

Representative cultures of all genera were tested for salt tolerance, as indicated by film formation on cucumber brine (see Figure 2). The rate of film formation was considered important, since this probably would be

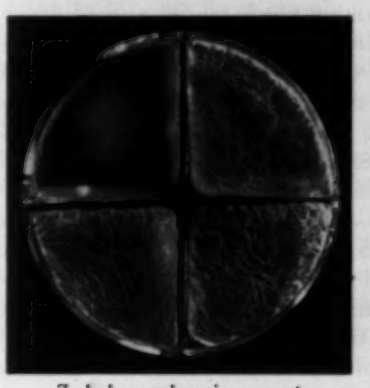


C. krusei

E. ohmeri nov. sp.



D. membranaefaciens var. *Holl.*



Z. halomembranis nov. sp.

FIG. 2. Growth of film yeast isolates on cucumber brines containing 5, 10, 15, and 20 percent salt by weight; 1-week's incubation at 25° C. After 2-week's incubation, the *Debaryomyces* species formed a heavy wrinkled film on 20 percent salt and the *Endomycopsis* formed a slight film; the *Candida* did not grow above 10 percent salt.

an influencing factor as to the predominance of a given yeast on a vat brine under suitable conditions of growth. All genera except the *Candida* isolates were capable of rather high salt tolerance as indicated by range of brine strengths from which they were obtained (Table 1).

No outstanding differences in final tolerance were found between the isolates of *Debaryomyces* and *Zygosaccharomyces*. Both groups produced luxuriant, folded films on cucumber brines at 20 percent salt by weight; isolates of the former genus took about 10 days, whereas the latter required only 5 days. The rate of film formation at lower concentrations (5, 10, and 15 percent) was essentially the same for both genera. The high salt tolerance of the *Debaryomyces* has been demonstrated earlier *(7)* and because of this these yeasts were considered to be more widely distributed on salt brines. We are in general agreement with this; however, another important factor is their ability to assimilate a wide variety of carbon compounds as a source of energy.

The cultures of *Endomycopsis* produced heavy, folded films at 15 percent salt in 5 to 7 days but there was little evidence of film formation at 20 percent until about 2 weeks. After that a rather thin film appeared. The isolates of this genus were divided into two groups: Those from laboratory source and those from commercial source. Cultures from both groups showed no difference with respect to salt tolerance, although certain differences in cultural characteristics and film formation on ethyl alcohol indicated a difference as to variety.

The *Candida* cultures showed a very clear-cut response to increasing salt concentrations. Film formation was absent on 15 and 20 percent brines. Ten percent appeared to be about the maximum, and the film at this strength was thinner than at 5 percent. This characteristic probably accounts for not finding more isolates of this yeast, since only 6 brines were sampled in the 5 to 10 percent range. The results for 3 *Pichia* cultures which were isolated from low-salt, high-acid content pickle products were essentially the same as for the *Candida* cultures. Mrak and Bonar *(7)* reported that their cultures of *Pichia* and *Mycoderma* isolated from food brines were "barely able to grow in brines containing 15.1 percent salt."

In the present work no cultures of *Mycoderma* were obtained. In the industry this genus is considered to be responsible for the films on salt-stock brines. But this investigation, as well as the work by Mrak and Bonar *(7)*, would indicate that species of *Mycoderma* would not be expected to predominate on brines in commercial practice (for brining cucumbers) where the starting strength is usually 7 to 10 percent by weight and is raised to 15 to 17 percent in about 6 weeks. Species of genera that are very salt-tolerant and fast-growing on brines of this strength would no doubt monopolize the surface of the brine and would be expected to restrict the less salt-tolerant types such as *Mycoderma* and *Pichia*. Earlier reports on film yeasts on brines were made prior to more modern taxonomic methods for yeast study *(1, 2, 10)* For example, without a test for mycelium production, differentiation between certain species of *Candida* and *Mycoderma* would be rather difficult.

Cultural and Biochemical Properties and Classification

Debaryomyces: Eighteen of the 22 cultures placed in this genus formed a uniform group according to the usual taxonomic tests. They are very poorly fermentative; glucose and sucrose may be weakly fermented. All the 7 test sugars are assimilated with a white, climbing film. On ethyl alcohol a dull, white film is formed with a fine network of folds. The film remains intact for a long period. On wort a moderately heavy film, light tan in color, with a network of short fine folds is produced. Potassium nitrate is not utilized. Cells, occurring in clusters, are round to slight oval and average 4-6 microns in diameter. Sporulation is after either isogamic or heterogamic copulation with 1 spore per ascus. Spores are spherical, rough, 3-4 microns in diameter with centrally located oil drop. Asci are 8 to 10 microns in length. Pseudomycelium is absent on corn meal agar. Glucose agar slant growth is chalky white, raised, folded. Folds change from white to tan, and then to brown color on vegetable juice agar as sporulation takes place. Salt-tolerance: heavy film formation at 20 percent; maximum not determined, probably close to saturation (26.4%). Type strains are FY-21, FY-22, FY-36; NFY-20.

Four cultures differ from the above descriptions in that they are inclined to be smooth on slants and produce thin films on ethyl alcohol. More precise and extensive carbon assimilation tests, such as reported by Wickerham and Burton *(11)* for the *Hansenula*, will be required to make any distinct separation. The brine isolates of *Debaryomyces* were not placed as to species other than on a tentative basis and are similar to several species that have been described *(10)*. But a number of the descriptions are so similar that separation is extremely difficult. The isolates of the present work are similar to *Debaryomyces membranaefaciens* var. *Hollandicus* Lodder.[b]

Endomycopsis: The isolates placed in this genus consisted of 12 cultures obtained from films on commercial brines, and 14 from films on cucumbers brined under laboratory conditions. All were placed in a new species of *Endomycopsis* based chiefly on the sugars fermented, and on the ability to produce a film on ethyl alcohol. The latter characteristic is negative for the species previously listed *(10)*. The name *Endomycopsis ohmeri* is suggested for the group and they are named for the late Harvey B. Ohmer who assisted in collecting the first isolates from films in eastern North Carolina. The type species represents the 12 isolates from commercial sources and are characterized by a heavy wrinkled film on ethyl alcohol. Varietal rank *(E. ohmeri* var. *minor)* was given to the 14 isolates from laboratory source and these cultures are readily differentiated by a membrane-type of film on ethyl alcohol and difference in the type of slant growth.

The characteristics for the new species and variety are

[b] Further separation is planned later in cooperation with Dr. L. J. Wickerham and coworkers of the Northern Regional Research Laboratory (Peoria), when they have completed the carbon assimilation patterns for the species of the *Debaryomyces* genus.

as follows: *Endomycopsis ohmeri nov. sp.:* Glucose, sucrose, galactose, and raffinose (⅓) are fermented. Maltose, lactose, and melibiose are not fermented but maltose and lactose are assimilated with formation of a smooth film. On ethyl alcohol, a white, heavy, wrinkled film is formed with close folds; broth is clear and the underneath portion of film is ragged; film wets and disintegrates in about 10 days. On wort, heavily wrinkled film is formed with a network of short folds, dark tan in color; growth ragged underneath film. Nitrate (KNO_3) is not utilized. The cells are slender, oval, very elongated; 3 x 4 microns to chains of 2 x 15 to 30 microns and branched. Hat-shaped spores produced on vegetable juice agar 1 to 4 per ascus; sporulation scant. Pseudomycelium abundant on cornmeal agar; evidence of true mycelium found. Glucose agar slant growth chalky white, coarsely netted, wet underneath surface. Salt tolerance: heavy film formation at 15 percent; scant to weak at 20 percent in 3 weeks. Type strains, FY-15, FY-25 and Y-470.

Endomycopsis ohmeri sp. nov.: Fermentationem glucosii, sucrosii, galactosii et raffinosii (⅓) inducens, sed non maltosii, lactosii, nec melibiosii; maltosium lactosiumque assimilantur pellicula levi; pellicula in alcoholi ethylico alba, crassa, plicis densis rugosa, infra lacterata liquido claro, humida, in circa 10 diebus disrumpens; in musto dense rugosa, fusca, plicis brevibus reticulata, infra lacertata; nitratum non utitur; cellulae angustae, elongato-ovales, 3-4 μ vel in catenis ramosis 2 x 15-30 μ longis; ascosporae pileiformes in agaro succus vegetabilium, 1-4 in quoque asco, sporulatione parca; pseudomycelium in agaro farinae-zeae abundans; mycelium verum evidens; auctus in agaro glucoso cretaceo-albus, crasse reticulatus, infra madidus; toleratio salis; formatio gravis pelliculae ad 15%, parca vel debilis ad 20% in 3 hebdomadibus.

Germina typica FY-15, FY-25, et Y-470.

Endomycopsis ohmeri var. *minor nov. var.:* Glucose, sucrose, galactose and raffinose (⅓) are fermented. Maltose, lactose and melibiose are not fermented but maltose is assimilated with a very heavy growth. On ethyl alcohol, a white, smooth intact membrane-type of film is formed which falls in a few days, either as a whole or in sections. On wort a heavy, wrinkled film with long folds is formed which is tan to brown in color. Nitrate (KNO_3) is not utilized. The cells are large oval to cylindrical in shape and may be in long chains. Cells 4 x 7-20 microns. Hat-shaped spores produced on vegetable-juice agar, 1 to 4 per ascus; sporulation scant. Pseudomycelium abundant on corn-meal agar; evidence of true mycelium found. Glucose agar slant growth yellowish, dry, mealy, finely netted. Salt-tolerance: Heavy film formation at 15 percent; scant to weak at 20 percent in 3 weeks. Type strains, FY-1, FY-7, and FY-14.

Endomycopsis ohmeri var. *minor* var. nov.: Fermentationem glucosii, sucrosii, galactosii et raffinosii (⅓) inducens, sed non maltosii, lactosii nec melibiosii; maltosium assimilatur aucto gravidissimo; pellicula in alcoholi ethylico alba, levis, integra, membranacea, in diebus paucas vel intacta vel in fragmentis delabens, in musto gravida, plicis longis rugosa, alutacea vel brunnea; nitratum non utitur; cellulae magnae ovales usque cylindricae, interdum in catenis longis, 4 x 7-20 μ; ascosporae pileiformes in agaro succus vegetabilium, 1-4 in quoque asco, sporulatione parca; pseudomycelium in agaro farinaezeae abundans; mycelium verum evidens; auctus in agaro glucoso flavidulus, aridus, farinosus, tenuiter reticulatus; tolerantia salis: formatio gravida pelliculae ad 15%, parca vel debilis ad 20% in 3 hebdomadibus.

Germina typica FY-1, FY-7 et FY-14.

Saccharomyces, subgenus *Zygosaccharomyces:* The 9 isolates placed in this genus were a uniform group and in view of their unusual characteristic of rapid and luxuriant film formation on high salt-content brines, they were considered to belong to a new species. The name *Zygosaccharomyces halomembranis* is suggested to conform with the characteristic that is so distinctive.

The complete description is as follows: *Zygosaccharomyces halomembranis:* Glucose and maltose are fermented; action on sucrose is variable, but this sugar may be fermented weakly. Lactose, galactose, raffinose, and melibiose are not fermented. Sucrose, galactose, and raffinose assimilated with heavy ring and sediment. Good growth in ethyl alcohol; ring but no film formation. Nitrate (KNO_3) not utilized. Pseudomycelium not found on corn-meal agar. Cells generally round to slight oval, 5 to 7 microns in diameter, occurring in clusters. Sporulation after either isogamic or heterogamic copulation 1 to 4 spores per ascus, usually 1 or 2. Spores average 3.5 x 4 microns in size, usually oval shape. Glucose slant growth, light cream color, raised, dull and may be finely papillate in center area of growth. Salt tolerance: Heavy, rapid film formation at 20 percent; maximum not determined, probably close to saturation (26.4%). Film formation negligible to absent in liquid media without salt. Type strains NFY-6, NFY-26.

Zygosaccharomyces halomembranis sp. nov.: Fermentationem glucosii, maltosii que etiam interdum sucrosii leviter inducens, sed non lactosii, galactosii, raffinosii nec melibiosii; sucrosium galactosium et raffinosium assimilantur, annulo et crassimine gravidis; auctus in alcoholi ethylico bonus, annulo praesenti sed pellicula carenti; nitratum non utitur; pseudomycelium non visum in agaro farinaezeae; cellulae plerumque rotundae vel subovales, 5-7 μ in diam., in greges confertae; sporulatio post copulationem isogamicam vel heterogamicam; ascosporae 1-4 (generaliter 1-2) in quoque asco, 3.5-4 μ, plerumque ovales; auctus in medio glucoso pallide cremeus, elevatus, obscurus, centro subtiliter papillatus; tolerantio salis: formatio pelliculae gravida et rapida ad 20%, maxima indeterminata, fortasse 26.4%, in mediis liquidis sine sale tenuis vel absens.

Germina typica NFY-6, NFY-26.

These characteristics are essentially the same as those for the 9 glucose, maltose fermenting cultures of *Zygosaccharomyces* recently described by Etchells and Bell *(3)*, but which were not placed as to species. These

yeasts came from subsurface brine samples of a sheltered vat which had a surface film. However, the ability to form films on brines was missed because salt-tolerance tests using liquid media were not run.

A test was made on the ability of three strains of *Z. halomembranis nov. sp.* to form films on cucumber brines of different salt concentration as compared with species and varieties in the genus *Zygosaccharomyces* which have similar carbon assimilation reactions. The 16 yeasts, selected and supplied by Dr. L. J. Wickerham of the Northern Regional Research Laboratory (NRRL) were: 1. *Z. mellis,* 2. *Z. barkeri,* 3. *Z. japonicus,* 4. *Z. japonicus* var. *soya,* 5. *Z. major,* 6. *Z. nadsonii,* 7. *Z. richteri,* 8. *Z. dairensis,* 9. *Z. rugosus* (2 strains), 10. *Z. amoeboideus,* 11. *Z. cavarae* var. *beauverie,* 12. *Z. felsineus,* 13. *Z. gracilis,* 14. *Z. major* var. *threntensis,* 15. *Z. salsus* var. *saccharosum,* and 16. *Z. polymorphus.* The above NRRL cultures were inoculated by loop from the original tubes into cucumber brines containing 5, 10, 15 and 20 percent salt by weight. Prior to inoculation into the test brines, the 3 strains of *Z. halomembranis nov. sp.* had not been on salt-containing media for approximately 2 years.

After 5 days the 3 strains of *Z. halomembranis* formed heavy folded films on the 15 and 20 percent salt brines and moderately heavy films on the 5 and 10 percent brines, whereas no film formation was observed for any of the 16 NRRL cultures. After 2-, 4-, and 8-week incubation periods the results were the same with respect to film formation for the 16 species tested. However, after two weeks heavy ring growth, turbidity, and sediment was noted at 10 percent salt for one species, *Z. mellis.* Furthermore, after 4 week's incubation all the 17 cultures tested had slight to moderate ring growth and increased sediment in 10 percent brine, and the first 8 cultures listed above showed definite signs of ring growth at 15 percent, but not at 20 percent.

The results indicate that the 16 species of *Zygosaccharomyces,* after 8 weeks' incubation, were not capable of film formation on cucumber brines ranging in strength from 5 to 20 percent salt by weight although a number of species were able to grow reasonably well in brines containing up to 15 percent salt. Thus *Z. halomembranis* can be readily separated from other *Zygosaccharomyces* species and varieties having similar fermentation and carbon assimilation reactions by virtue of rapid and luxuriant film formation on high salt-content brines or salt-containing liquid media.

Candida: The 4 cultures in this genus were placed as *C. krusei* (A. Cast.) Berkhout and are characterized by the fermentation of glucose only. Sucrose, maltose, galactose, lactose, raffinose and melibiose are not fermented nor assimilated. A very thin film appears on these sugars but it is attributed to assimilation of the slight amount of acid in the basal medium. On ethyl alcohol, a white, moderately heavy film, composed of a fine network of folds; on wort, a similar film is formed but it is light tan in color. Potassium nitrate is not utilized. Cells are large, rod-like, cylindrical in shape; also large oval cells. Cells average 2.5-3 x 4 to 35 microns and occur in chains. Pseudomycelium is abundant on corn-meal agar; septated mycelium is present. No spores are observed on several sporulation media, observed over several months. Glucose slant growth is white, dull, flat, not folded, or wrinkled; edge spreading and fuzzy. On vegetable juice agar a very fine network develops in the center of slant growth. In respect to salt tolerance; moderate film formation at 10 percent but none at 15 percent. Type strains are FY-18, FY-19, FY-20.

De-esterification of pectin: An interesting biochemical property was observed in connection with the growth of cultures from two of the film yeast genera in a liquid medium at pH 5 containing 0.5 percent salt, 0.5 percent peptone, 0.25 percent yeast extract, and 0.5 percent citrus pectin (purified, free of sugars). Representative isolates of *Endomycopsis* and *Debaryomyces* were capable of de-esterifying the pectin in the medium so that a gel was formed upon the addition of one drop of a 20 percent calcium chloride solution to 0.5 ml. of the culture medium. At present, the exact nature of the reaction has not been determined. The *Zygosaccharomyces* and *Candida* isolates obtained in the present study were negative for the above test; however, three cultures of *Candida,* representing two different species, previously isolated from brines were positive.

Summary and Conclusions

A taxonomic study of 47 yeast cultures associated with the production of surface films on 40 commercial cucumber pickle brines ranging in salt content from 5-19 percent salt, and located in five states, is presented.

The cultures were classified as follows: *Debaryomyces membranaefaciens* var. *Hollandicus* Lodder 18 isolates; *Endomycopsis ohmeri nov. sp.,* 12; *Zygosaccharomyces halomembranis nov. sp.,* 9; and *Candida krusei* (A. Cast.) Berkhout, 4. Four cultures put in the *Debaryomyces* genus were not placed as to species.

An additional 14 isolates of *Endomycopsis* obtained from a like number of films on cucumbers brined under laboratory conditions were given varietal rank in the new species as *Endomycopsis ohmeri* var. *minor.*

Yeasts belonging to the genus *Debaryomyces* were the most widespread, and were found on brines in all five states. Their high salt tolerance coupled with the ability to assimilate a large number of compounds as a source of carbon were considered to be important factors in their frequency of occurrence and distribution. Yeasts belonging to the genera *Zygosaccharomyces* and *Endomycopsis* have not previously been considered associated with film formation on cucumber brines or other types of food brines.

Sixteen species and varieties of *Zygosaccharomyces* with carbon assimilation reactions similar to the new species *Z. halomembranis* were tested for film formation on cucumber brines at 5, 10, 15 and 20 percent salt concentration. Negative results for film formation were obtained for the known cultures observed for a period up to two months, whereas heavy films were produced by *Z. halomembranis* in five days.

Representative cultures placed as species in the *Debaryomyces* and *Endomycopsis* genera were capable of de-esterifying citrus pectin in a cultural medium.

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Detection of Glutamate and Hydrolysate Added to Foods[a]

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A simplified form of paper chromatography has been developed for detecting the presence of added glutamate in processed foods, and determining whether the addition has been made in the form of pure monosodium glutamate or as one of the components of a protein hydrolysate.

Recently the Food and Drug Administration ruled that food labels need not designate added monosodium glutamate as an artificial flavoring, since it has no flavor of its own when used in foods but merely serves to intensify the natural flavors. It is to be expected that this ruling will result in more widespread use of the material by food processors. Its presence in processed foods is easily detected by means of a simplified modification of the test tube method of paper chromatography previously described by Rockland and Dunn for general use *(2)*. This technique is also capable of indicating whether glutamate has been added as the pure salt or as one of the components of an entire protein hydrolysate or a fraction thereof, in which it is invariably accompanied by substantial quantities of other amino acids which appear on the papergrams.

Most processed foods contain liquid which may be sampled directly. If the food sample contains no liquid, water is added. The food is mixed, and a sample is taken by dipping the end of an unused round wooden applicator stick (2 x 152 mm.) into the liquid portion. Excess liquid is blotted off on a piece of filter paper, leaving just enough liquid to make a moist impression without spreading appreciably on the paper. Strips of Whatman No. 1 filter paper are prepared by cutting to 16 x 130 mm. and creasing into V-shape troughs.

Two sample spots are placed on each strip, in the center of each side about 2 cm. from the bottom end. After the spots have dried, each strip is lowered into a slightly tilted test tube (about 18 x 150 mm.) containing about 1 ml. 80% analytical grade phenol *(1)*. The strip should touch glass only at the bottom end and the two outside top corners. The test tube is stoppered and allowed to stand until the phenol has risen within 1 cm. of the top of the paper (about two hours). The strip is then removed and allowed to dry. The surface is then sprayed lightly with n-butanol saturated with water, and containing 0.25% ninhydrin and 1.0% acetic acid. Color is developed by heating several minutes, in an oven or before a 250 watt heat ray lamp.

Fig. 1 shows papergrams obtained from chicken soup to which either monosodium glutamate (MSG) or a

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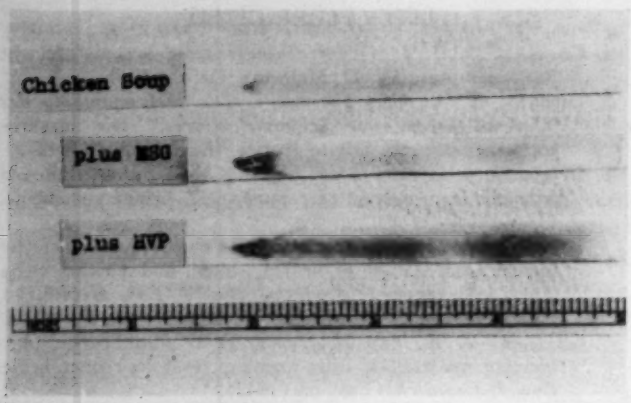

FIG. 1. Detection of Monosodium Glutamate vs. Hydrolyzed Vegetable Protein Added to Chicken Soup.

hydrolyzed vegetable protein (HVP) has been added at a level of 0.1% amino acid equivalent. It will be noted that in this particular instance the unfortified chicken soup produced a slight amino acid spectrum. We have never encountered a food in which this "blank spectrum" was sufficiently strong to interfere with the test. After adding MSG, the glutamic acid spot appeared larger and considerably darker, while the rest of the "spectrum" remained unchanged. On the other hand, the addition of HVP produced dark streaks, indicative of the presence of other free amino acids. Such visual comparison, it should be noted, is quantitative to a certain extent. For instance, the fact that the level of added glutamic acid from MSG was higher than from HVP is readily apparent. While applicator sticks produce sufficiently uniform spots for ordinary purposes, for such quantitative comparisons it is better to prepare filtrates and apply equal volumes to the strips with a micropipet.

Many well-known processed foods have been tested by the above method. Typical results are shown in Fig. 2. The papergrams shown resulted from samples of (1) MSG, (2) HVP, (3) HVP added to chicken soup in the laboratory, and (4) commercial soy sauce.

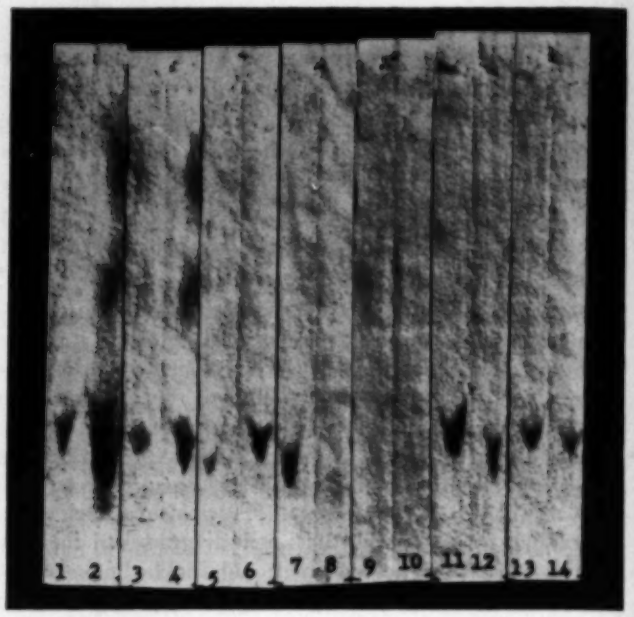

FIG. 2. Papergram Detection of Glutamate Fortification in Processed Foods.

Papergrams 5-10 were obtained from canned chicken products; the first three show that MSG has been added, while the second three show that MSG has not been added. Papergrams 11-14 represent four other varieties of canned soup, all showing by this test the presence of added MSG.

The technique described has also been found advantageous for detecting other amino acids, often showing greater sensitivity than the macro-methods. We have found it equally successful using collidine-lutidine instead of phenol.

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A Comparison of Chemical Changes in Mackerel Tissues Treated by Ionizing Radiation[a]

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Irradiation from an electrostatic generator made possible a comparison of enzymatic with bacterial changes in mackerel tissues. Organoleptic, chemical, and physical tests, and bacterial counts were made at two day intervals during an eight day storage of fish tissues.

Introduction

Although it has long been recognized that the decomposition of fish is due to the action of both bacteria and enzymes, it has been established that bacterial action plays a more important part than enzymatic autolysis in causing the staling of certain fish, notably haddock and cod *(1, 11)*. In the case of mackerel, however, enzyme action is considered to be of relatively great importance.

Little literature is available that deals primarily with the mechanism of the decomposition of mackerel. Stansby and Lemon in 1941 *(9)* carried out a fairly extensive investigation on mackerel, including a study of the chemical changes in the fish during storage under defi-

[a] Presented before the Ninth Annual I. F. T. Convention, San Francisco, California, July 12, 1949.

nite conditions, but this investigation was not concerned with the causes of decomposition. They found that the oil content of mackerel varied greatly, being much higher in late summer than in spring. "Red feed" ("Calanus finmarchicus"), when present in the digestive tract of mackerel, accelerated the spoilage rate. Organoleptic methods of testing were found to be the best means of judging freshness, and recommendations were made for methods of commercial handling of mackerel.

The relative importance of bacteria and enzymes in causing fish decomposition has never been established beyond doubt, because methods have not been available whereby the bacteria in and on fish tissues could be destroyed without inactivating the enzymes present therein. During the last few years it has been shown that bacteria in food products can be destroyed by supervoltage ionizing radiations used in moderate dosages *(2, 7)*. Much larger dosages of radiation were required to inactivate enzymes in foods *(2, 4)*.

As irradiation methods were available in these laboratories for destroying the bacteria in fish tissues without inactivating the enzymes in such products, it appeared that an investigation to establish the extent of enzymatic and bacterial action in fish tissues held under definite storage conditions would be of considerable interest. Mackerel (Scomber scombrus) was selected as the species with which the research would be concerned.

This project was designed to study the mechanism of spoilage rather than to determine the stage of decomposition at which the product could no longer be considered as fresh. Chemical tests used for the purpose of following spoilage changes were selected to indicate the type and the rate of decomposition that was taking place. The suitability of such tests to demonstrate the general conditions of the fish was considered to be of secondary importance.

Experimental Procedure

A number of mackerel were obtained during the early part of December, approximately four days after they had been caught. These fish were in excellent condition upon arrival. Some of these mackerel were packed intact (uneviscerated or "in the round") in crushed ice, to be tested after storage. Other mackerel of the same lot were filleted, and the fillets were placed in polyethylene tubes which were heat-sealed. One fillet from each cut fish was placed in crushed ice for test after storage. The other fillet from the same fish was irradiated with supervoltage cathode rays and then placed in crushed ice. An irradiation dosage of 1,500,000 roentgens-equivalent-physical (rep) was used. Bacteriological and chemical tests were made on both unirradiated (control) and irradiated paired fillets and on whole fish at the start and also after storage periods of 2, 4, 6, and 8 days.[b]

Samples were excised by aseptic techniques for bacterial counts, and the remainder was ground for chemical tests. In the case of fillets, the polyethylene tubing was first cut open, after which 22-gram portions of tissue were cut out with sterile implements, transferred to sterile Waring Blendor tops containing 198 ml. of sterile water, and disintegrated for 2 minutes. This served as a 1:10 dilution. Other dilutions were made in the usual manner. Whole mackerel were cut down the back and the fish were laid open. The intestines were moved aside with sterile implements, and 22-gram portions of flesh were excised from the belly tissues against which the intestines had been lying. Dilutions were made in the usual manner.

Tryptone-glucose agar was used as a culture medium, and plates were incubated for 72 hours at 30° C. before counts were made.

Anaerobic counts were made on irradiated fillets and on whole mackerel on the fourth and the sixth day of storage, the culture samples being taken from those excised for aerobic counts. The spray-plate method for anaerobic cultures was used, and liver-veal agar was the culture medium. All cultures were incubated at 30° C. for 72 hours before they were examined.

The whole fish, after being examined for bacteriological count, was filleted to facilitate the carrying out of chemical tests. All fillets were comminuted in separate containers. Each comminuted portion was then mixed, comminuted again, and remixed.

Prior to the chemical tests, determinations were made with a Beckman pH meter to find the pH of comminuted tissue samples.

Material for trimethylamine and amino nitrogen determinations was obtained by weighing 40 grams of comminuted tissue into blendor tops, adding 40 ml. of water and 80 ml. of 10 percent trichloracetic acid solution, and disintegrating thoroughly by blendor action. The disintegrated product was filtered through fine filter paper, and the extract used for the following two tests.

(1) The method of Dyer *(3)* was used for trimethylamine nitrogen determinations.

(2) Amino nitrogen was determined according to the method of Pope and Stevens *(6)*.[c]

To determine the content of volatile acids, a 20-gram sample of comminuted, mixed flesh was weighed into a 300-ml. Kjeldahl flask, 50 ml. of distilled water was added, and the mixture was shaken. To this were added 8 ml. of 8 N sulfuric acid and 30 ml. of a 10 percent aqueous solution of phosphotungstic acid, and then 16 grams of magnesium sulfate. The steam distillate was collected in 200-ml. portions, which were titrated with 0.01 N sodium hydroxide solution. Phenolphthalein was used as an indicator. Blanks were run on 200 ml. of distilled water, and these were subtracted from the titration values for the unknown.

To determine the oil content of comminuted samples, 25-gram portions were weighed into 250-ml. glass-stoppered Erlenmeyer flasks, 25 grams of anhydrous sodium sulfate was added to each flask and mixed with the sample, and then 100 ml. of anhydrous ether. The

[b] The cathode ray equipment used was a Van de Graaff electrostatic generator operating at 3 M. E. V. and has been thoroughly described elsewhere *(8, 10)*.

[c] This test was found to give more consistent results when the copper phosphate suspension was prepared just prior to use, from stock solutions of cupric chloride, trisodium phosphate, and borate buffer.

flasks were stoppered and shaken mechanically for one hour. Then 25-ml. portions of the ether extract were removed (a) for evaporation to dryness to determine the oil content and (b) for determinations of peroxide and free fatty acid contents.

The peroxide and free fatty acid tests were made on ether extract portions according to the method of Stansby and Lemon *(9)*.

Duplicate chemical tests were made in all cases and the results averaged.

One fillet was placed in polyethylene tubing, irradiated by 1.5×10^6 rep of cathode rays, and held for 30 days, at room temperature. This sample was observed periodically for macroscopic changes.

In the early part of April, two mackerel were obtained approximately one day after they had been caught. These fish were held intact (uneviscerated, "in the round"), in crushed ice. After four and seven days of storage, one fish was removed and chemical tests were made on flesh and on intestinal samples. The samples were comminuted prior to being tested, as with the former lot of fish.

Because it seemed that hydrogen sulfide might be produced during decomposition of mackerel, several fish were obtained in June, two days after being caught, and were held intact (uneviscerated and "in the round") in crushed ice. Hydrogen sulfide tests were made on comminuted tissues and on comminuted intestines.

The pH of the contents of the intestinal tract was determined with a Beckman pH meter.

Hydrogen sulfide was determined by placing 25 grams of comminuted tissues in a 250-ml. Erlenmeyer flask, then adding 15 ml. of distilled water and 50 ml. of 10 N hydrochloric acid. The mouth of the flask was covered with a moistened filter paper, which had previously been treated with a 10 percent lead acetate solution and dried. A block of wood was placed on top of the paper. Flasks prepared in this manner were incubated at 55° C. for 10 minutes, after which the lead acetate paper was removed. This method was found to be only crudely quantitative, but increases in hydrogen sulfide content could be noted by a deepening of the color of the lead acetate paper produced by the hydrogen sulfide evolved from the sample during incubation.

Discussion

The results of the organoleptic, chemical, and physical tests and of the bacterial counts on the mackerel caught in December are summarized in Table 1, and the results of the chemical tests on the mackerel caught in the spring in Table 2.

In whole mackerel held in ice, both enzymatic action and bacterial action took place to a considerable extent. Bacterial action was confined to the intestines, but enzymatic action was evidenced in the tissues themselves as well as in the intestines.

Hydrogen sulfide was found to be present in the tissues and to a greater extent in the intestines of whole mackerel held in ice. (See Figure 1.) The amount present in either tissues or intestines was found to increase during storage in ice, as indicated by a crudely quantitative method. Inasmuch as hydrogen sulfide is known to be an end product of bacterial decomposition and no bacteria were found to be present in the tissues

TABLE 1

Organoleptic, Chemical, and Physical Tests and Bacterial Counts on Mackerel Held in Ice—Fall Fish

Type of Test	Storage in Ice After Caught				
	4 days	6 days	8 days	10 days	12 days
Organoleptic					
Whole fish	Very good	Good	Stale	Stale	Stale and rancid
Control fillet	Very good	Very good	Good	Rancid	Rancid
Irradiated fillet	Very good	Very good	Good	Rancid	Rancid
Trimethylamine nitrogen[d]					
Whole fish	2.10	3.92	3.12	4.20	12.00
Control fillet	2.10	1.04	2.70	4.52	16.00
Irradiated fillet	1.58	1.56	2.00	3.24	4.06
Amino nitrogen[d]					
Whole fish	48.17	.....	72.50	91.80	93.97
Control fillet	48.17	.....	58.57	50.47	69.22
Irradiated fillet	46.32	.....	38.83	50.60	65.14
Volatile acids[e]					
Whole fish	18.98	34.65	58.85	69.25	196.46
Control fillet	18.98	15.90	34.80	39.60	93.50
Irradiated fillet	23.54	20.90	30.86	33.22	43.89
Peroxide number of oil					
Whole fish	.....	0.0	2.90	2.82	9.10
Control fillet	.....	0.0	2.10	8.98	4.75
Irradiated fillet	.....	0.0	5.30	7.00	6.77
Free fatty acids in oil[f]					
Whole fish	.....	.....	0.86	1.16	2.70
Control fillet	.....	.....	0.83	1.02	1.65
Irradiated fillet	.....	.....	0.92	0.98	1.23
pH of ground flesh					
Whole fish	6.29	6.18	5.82	6.02	5.95
Control fillet	6.29	6.29	5.86	5.89	5.99
Irradiated fillet	6.22	6.29	6.01	6.12	5.98
Bacterial count[g]					
Whole fish	800	300	< 100[h] no anaerobes	< 100[h] no anaerobes	910,000 entrails broken
Control fillet	8,000	11,200	46,500	550,000	5,500,000
Irradiated fillet	< 10[h]	< 10[h]	< 10[h] no anaerobes	< 10[h] no anaerobes	< 10[h] no anaerobes

[d] mg. per 100 gm. flesh. [e] ml. N/100 NAOH used per 100 gm. flesh. [f] Percent as oleic. [g] Bacteria per gram. [h] Less than (<) indicates no bacteria found in the lowest dilution made.

TABLE 2

Chemical Tests on Flesh and Viscera of Whole Mackerel Held in Ice—Spring Fish

Type of Sample	Type of Test	Unit of Measurement	Days in Storage After Caught	
			4 days	7 days
Ground flesh	Trimethylamine nitrogen	mg. per 100 gm. of sample	1.41	2.72
Ground viscera	Trimethylamine nitrogen	mg. per 100 gm. of sample	30.50	54.50
Ground flesh	Amino nitrogen	mg. per 100 gm. of sample	37.20	52.60
Ground viscera	Amino nitrogen	mg. per 100 gm. of sample	260.0	366.0
Ground flesh	Volatile acids	ml. N/100 NAOH used per 100 gm. of sample	14.46	16.82
Ground viscera	Volatile acids	ml. N/100 NAOH used per 100 gm. of sample	204.0	276.0

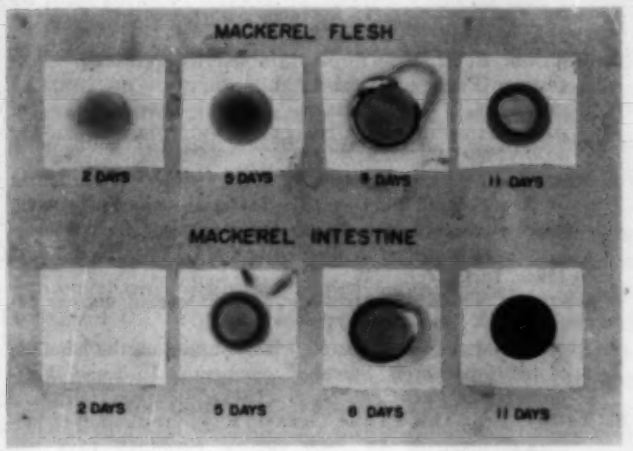

FIG. 1. Relative Amounts of Hydrogen Sulfide Evolved by non-irradiated Mackerel Tissues During Storage in Ice.

of whole fish, it is assumed that hydrogen sulfide effused through the intestines into the tissues.

Trimethylamine, also a product of bacterial action, was produced in the intestines in large amounts but did not effuse into the tissues.

The fact that the pH of the intestinal contents was found always to be on the acid side may be the reason that hydrogen sulfide accumulated in the tissues whereas trimethylamine did not.

No bacterial action took place in the tissues of whole mackerel held in ice, until after the intestines broke. This was indicated by the results of both chemical tests and bacterial counts. At no time prior to the breaking of the intestines could the presence of more than a few hundred aerobic bacteria per gram of flesh be found in the tissues. Anaerobic bacteria were not present at the end of 10 days' storage in ice, two days before the intestines broke.

The inner belly tissues lying against the intestines were used for bacteriological samples and, if bacteria were present in the flesh, it should have been possible to culture them from such portions. It is probable that the few bacteria found in belly tissues were introduced through contamination in taking the sample, although this has not been established as a fact. Even though the belly tissues autolyzed to a jelly-like consistency, they were essentially sterile until that period of storage in which the intestines were found broken.

Enzymatic action in the flesh of whole mackerel held in ice was more extensive than in cut fillets held under the same conditions. The products of enzymatic action were produced in great quantities in the intestines. It is doubtful that these products effused into the flesh, for volatile acids, which may be produced either by bacteria or by enzymes (lipases), accumulated in the intestines in considerable amounts but did not accumulate in the tissues of the same fish.

Volatile acids accumulated in the tissues of whole Fall fish during storage in ice, but did not accumulate to any extent in the tissues of whole Spring fish held under the same conditions. Fall mackerel have been found to contain much oil, whereas Spring mackerel have been found to be low in oil content *(9)*. It would appear, therefore, that the production of volatile acids in the tissues of whole mackerel held in ice may depend upon the action of lipases on the oils present therein.

Enzymatic action of the tryptic type was found to be similar in extent in paired control and irradiated (non-sterile and sterile) fillets. Volatile acids were produced in greater quantities in control than in irradiated fillets only after bacterial action became a factor. This indicated that there had been no appreciable inactivation of proteolytic and lipolytic enzymes by irradiation with cathode rays.

It was evident from the results of holding these products in ice for different periods of time that no better quality was obtained by filleting the mackerel, for the fillets became rancid at about the same time that stale odors became noticeable in the flesh of whole mackerel.

The pH of comminuted flesh tissues from fillets and from whole, uneviscerated mackerel showed a tendency to decrease during storage in ice.

This investigation was not carried out for the purpose of developing a method to determine the freshness of mackerel. However, the results of various tests used to evaluate changes in mackerel during storage in ice indicate that the amino nitrogen determination of Pope and Stevens *(6)* may have applicability for this purpose.

The concept *(5)* that flesh foods may completely autolyze when excised aseptically and held in sterile condition appears to be subject to question. One irradiated mackerel fillet was held at room temperature in a sealed polyethylene tube for 30 days. At the end of this period the physical appearance showed little change except for a discoloration in spots, ascribable to rusting and rancidification of the oil.

Conclusions

1. Bacterial action (as indicated by chemical tests for decomposition and by aerobic and anaerobic bacterial counts) did not take place in the flesh of whole, uneviscerated mackerel held in ice, so long as the intestine was intact. The quality of the fish had deteriorated greatly, however, prior to the breaking of the intestinal membrane, and the fish was not considered edible at that time.

2. Stale odors accumulated in the flesh of whole, uneviscerated mackerel as they were held in ice. One of the compounds produced in the intestines was hydrogen sulfide, which effused into the tissues.

3. Trimethylamine (a product of bacterial action) and volatile acids (produced by both bacteria and enzymes) were present in large amounts in the intestines of whole mackerel held in ice. These products did not effuse through the intestines into the flesh.

4. Trimethylamine did not increase significantly in the flesh of whole mackerel held in ice, until after the intestines broke. There were only slight increases in the trimethylamine content of irradiated (sterile) fillets held in ice. The trimethylamine content of unirradiated (not sterile) fillets remained virtually constant until bacterial increases were noted.

5. Enzymatic action (autolysis) took place to a much greater extent in the flesh of whole, uneviscerated mackerel held in ice than in either irradiated (sterile) or unirradiated (not sterile) fillets held under the same conditions.

6. The proteolytic action of enzymes in mackerel flesh was nearly as potent in irradiated as in non-irradiated tissue. Regardless of this fact, sterile (irradiated) mackerel tissues did not change in physical appearance during storage for 30 days at room temperature, except that the oil became rancid, which caused rusting.

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Browning and the Fluorescence of Evaporated Milk[a]

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Chemical changes occurring in evaporated milk upon sterilization are discussed. It is apparent that browning, fluorescence, and CO_2 production are highly associated. The fluorescent materials arise from changes in the protein fraction. A method for the release and measurement of the fluorescent material is given and it is suggested that this characteristic may be used as an objective measure of the quality of milk sterilized by heat. Data indicate that high-temperature short-time sterilization will produce a superior quality of evaporated milk with respect to brown discoloration and caramelized flavor.

The browning reaction, i.e., the non-enzymatic darkening or browning of food material during processing, and/or storage, has been the subject of intensive studies in recent years. Various aspects of the reaction in relation to the quality of different foods have been discussed by Kaufman *(8)* and Barnes and Kaufman *(2)*. In general, except for a few instances such as in in the drying of malt and in baking, the changes associated with the browning reaction in foods (dried fruits, dried eggs, dried fish and meats, dried milk, dehydrated vegetables) are deleterious to the quality *(1, 2, 8, 15, 16, 17)*.

In the field of dairy products, the development of brown color and the flavor changes associated with browning are of greatest importance in evaporated milk. The manufacture of evaporated milk represents the principal method of preservation of milk depending upon thermal sterilization of condensed milk in hermetically sealed containers. The standard temperature and time used for sterilization of evaporated milk is 242° F. (117° C.) for 15 minutes. Subjecting condensed milk to such heat treatment produces, among other changes, a cooked or caramelized flavor and a brown discoloration of the product. The degree of discoloration, as well as the intensity of the caramelized flavor, is known to be influenced by the pH of milk *(23)*, the lactose concentration *(7, 22)*, and the time and temperature of heating *(10, 18, 23)*. Other factors, but of minor importance, which affect the degree of browning are the extent of contamination of milk with copper and the amount of stabilizing salt (Na_2HPO_4) that may be added *(19)*.

Many changes are known to occur in milk as a re-

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sult of heating. In the course of browning there is a decrease in the concentration of lactose with the formation of acids, mainly lactic and formic *(5)*. There is no agreement in the literature on the effect of browning on the proteins of milk, except for a decrease in stability. Wright *(24)* maintains that the casein of autoclaved milk is essentially unaltered since the racemization curves of caseins from raw and autoclaved milks are identical. Tarassuk *(18, 20)* found that in sterilization of milk by heat, oxygen is taken up and carbon dioxide is produced. The reaction was attributed to the oxidation of lactose since similar results were obtained by heating an aqueous solution of recrystallized lactose. The browning of the lactose solution was inhibited almost entirely when the mixture was heated in an atmosphere of nitrogen containing less than 0.1 percent of oxygen *(20)*. Removal of the dissolved oxygen of evaporated milk by deaeration and replacing the air in the free space of cans by nitrogen prior to sterilization produced only a limited improvement in the color and flavor of the product. When a solution of lactose and an amino acid was heated in an atmosphere of nitrogen, browning, as in the case of the evaporated milk, was only slightly inhibited. Tarassuk *(20)* therefore concluded that the browning of milk by heating is not just a caramelization of lactose as proposed by Kass and Palmer *(7)* but is the Maillard type of reaction[c] (of aldehyde-amino groups) to which the browning of dehydrated foods has generally been attributed *(2, 9, 11)*.

Recently, flourescence has come to the fore in the study of the browning reaction. According to Thistle et al. *(21)*, the fluorescence value is the best single choice for measuring the extent of deterioration of palatability resulting from browning. Dutton and Edwards *(4)* working with dehydrated eggs reported the material resulting from browning to be identical with that causing fluorescence. Kline and Stewart *(9)* working with dried egg albumin confirmed this to the extent that the color and fluorescence reactions are parallel. Jenness and Coulter *(6)* have reviewed the literature on fluorescence in dairy products extensively and have made fluorescent measurements on different fractions of milk. They reported that heat treatment of milk in the range of 145° F. (63.0° C.) to 195° F. (90.5° C.) for 30 minutes had some effect in increasing fluorescence. The processes of condensing and spray drying had no significant effect. No work has been reported on the effect of sterilization temperatures on the fluorescence of milk nor on the changes in fluorescence in the course of browning of dairy products. The present study deals with changes in gases and fluorescence with respect to the browning of evaporated milk.

Materials and Methods

Evaporated milk used in these experiments was processed under standard commercial conditions unless described otherwise. For containers the standard size 14½ ounce cans were employed. Gas analyses were made according to the procedure of Peters and Van-Slyke *(13)* with Haldane gas apparatus and accessory equipment, as described by Blatt and Tarassuk *(3)*. The degree of browning or the color of milk was determined by the use of a "Lumetron," a photoelectric tristimulus colorimeter designed to measure the percentage of reflectance of an opaque substance such as evaporated milk as compared to a color standard such as MgO. Readings were obtained in the three tristimulus color bands—blue, green, and amber, designed to compare closely with the so-called standard observer.

Extracts of evaporated milk for the determination of fluorescence of the various milk constituents were prepared according to the method of Jenness and Coulter *(6)*. The fluorescence values were obtained with a Lumetron using a B-1 filter and a standard fluorescein solution containing 2γ/ml. The results were read as direct slide wire readings. The pH measurements were made with the Beckman glass electrode pH-meter.

Additional experimental procedures are included under experimental results and discussion.

Experimental Results and Discussion

Tarassuk *(18, 20)* has shown that in sterilization of milk by heat, oxygen is taken up and carbon dioxide is produced and that these gaseous changes parallel the time and temperature of heating as well as the intensity of the cooked or caramelized flavor and the degree of brown discoloration. Fig. 1 represents the extent and rate of these changes upon sterilization and upon prolonged storage at room temperature, 68°-77° F. (20°-25° C.). The samples of evaporated milk used in this experiment were from a commercial plant and had been sterilized at 243° F. (117.5° C.) for 13.5 minutes.

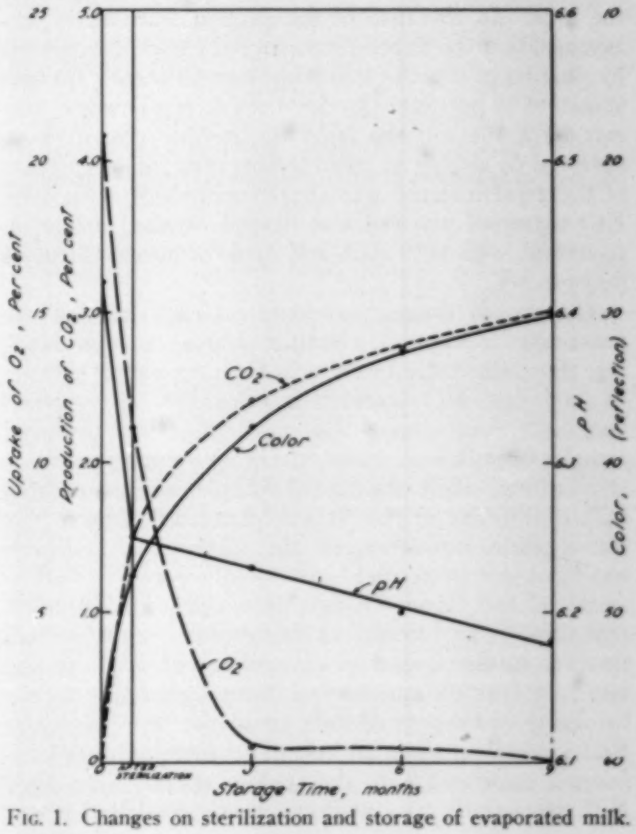

FIG. 1. Changes on sterilization and storage of evaporated milk.

[c] This is in agreement with earlier investigations on browning of milk by Orla-Jensen and others whose work was reviewed in our prior publication *(20)*.

The sterilization of the milk resulted in a reduction in the O_2 content in the free space to about one half its original value. The uptake of O_2 during the first three months of storage following sterilization continued, but at a slower rate, dropping from 20.9 percent (before sterilization) to 0.5 percent. In another series of samples, the O_2 content after 4 months of storage was 2.65 percent. Apparently there is some variation in gas changes as well as in the color and flavor of evaporated milk, probably depending upon the season, feed, and other variables. After 9 months of storage, the atmosphere of the free space in the can contained less than 0.05 percent of O_2. The CO_2 production during the process of sterilization appeared to be at about the same rate as the uptake of O_2. In storage it proceeded at a slower rate. It is interesting to note that the CO_2 production continued even after the O_2 supply was practically exhausted. The rate and the extent of brown discoloration at all times followed the production of the CO_2. Stadtman et al. *(14)* found a similar correlation between CO_2 production and nonenzymatic browning in the case of stored dried apricots.

Changes in Fluorescence. In order to determine what constituents of milk are responsible for the change in fluorescence, if such change does take place upon sterilization or storage, the evaporated milk was separated into three fractions according to the method described by Jenness and Coulter *(6)*. Fraction I consisted of an acetone-water extract and represented primarily lactose, salts, and the water-soluble nitrogenous material of milk. Fraction II was an acetone-ether extract of the precipitated residue from the first extraction and was essentially the lipide fraction. Fraction III was the residue of Fraction II and represented the protein fraction of the milk. In the case of the protein fraction, it was assumed that the fluorescing material could be extracted by shaking in 10% KCl, as Thistle and Pearce *(21)* had shown to be possible with dried whole egg powder. Accordingly, the solvents from the residue protein were removed by drying at room temperature, and one gram of the dried material was shaken with 10% KCl. The KCl extracted material was filtered, washed, made up to 100 ml. with 10% KCl, and used for measurement of fluorescence.

The typical fluorescence data on each fraction are presented in Table 1. Extract I gave a high reading, due principally to the riboflavin present. Extract II and the KCl extract of Fraction III showed very little fluorescence. The unsterilized and sterilized samples of milk were identical except for the process of sterilization, while the stored sample was evaporated milk of different origin. It will be noted that there was but a little difference in the fluorescence between sterilized and unsterilized milk. Only evaporated milk, sterilized and stored for two years, gave an indication that there is an increase in fluorescence in the protein fraction, as determined by extraction with KCl. It was apparent that the question of fluorescence due to the browning of evaporated milk could not be resolved by KCl extraction, since all of the browning material remained associated with the protein residue even after KCl extraction. The attempts to remove the browning material from the protein precipitate by the use of fat solvents, dilute and strong alkali and acids, salt solutions, and oxidizing and reducing agents, were ineffective.

Release of Color and Fluorescence by Enzymatic Hydrolysis

It was thought that enzymatic breakdown of the protein would release the colored compound. Papain and pancreatin, each at its optimum temperature and pH, were employed.

The digestion studies revealed that at least eight hours were required to release the maximum of browning material into solution, while only four hours were necessary to release the maximum of fluorescing material. The method adopted for the release of fluorescence was as follows. To one gm. of dried protein residue, 0.1 gm. of powdered pancreatin preparation (Pfanstiehl Chemical Company) was added and the mixture suspended in 50 ml. of citrate phosphate buffer of pH 7.0. Following incubation at 37° C. (98.6° F.) for 4 hours, the material was made up to 100 ml. and filtered through a fine (Whatman No. 42) filter paper, obtaining a water-clear colored filtrate. An aliquot of the filtrate was used for measuring the fluorescence.

TABLE 1

Release of Fluorescence by Enzymatic Hydrolysis

Treatment of Sample	Net Fluorescence				
	Fraction I	Fraction II	Fraction III		
			Extractions		
			KCl	Papain	Pancreatin
			per g. protein	*per g. protein*	*per g. protein*
Unsterilized	54.2	3.6	1.8	4.3	3.7
Sterilized	59.6	4.0	4.2	26.3	34.7
Sterilized and Stored for two years	42.6	3.4	11.0	41.1	52.3

Representative data obtained on the enzymatic release of fluorescence from the protein residue are included in Table 1. It is evident that subjecting milk to heat treatment, such as is used in sterilization, causes a marked increase in fluorescence. The chemical changes responsible for the increase in fluorescence proceed in storage, as can be seen from the data on the sample of evaporated milk stored for two years. Furthermore, it is evident that the sources of increased fluorescence resulting from sterilization or storage are the proteins of milk. The preliminary data indicate that fluorescence similar to the browning material *(7)* is associated with the casein of milk.

The evidence that the proteins of milk are the only source of increased fluorescence due to browning is at variance with the sources of fluorescence in stored dried eggs. In this product, Dutton and Edwards *(4)* have shown that a considerable increase in fluorescence comes from the lipide fraction.

Pearce *(12)* working with dried egg powder postulated that a portion of the fluorescence associated with browning results from hydrolytic deterioration of egg protein. Olcott and Dutton *(11)*, on the other hand, state that fluorescence is due to the browning reaction products of sugar and free amino groups of proteins,

and not to the hydrolytic products. The data of the present study (see Table 1) show clearly that fluorescence in evaporated milk resulting from the browning reaction cannot be attributed to hydrolytic deterioration.

The relationship between development of brown discoloration and fluorescence is illustrated in Fig. 2. The

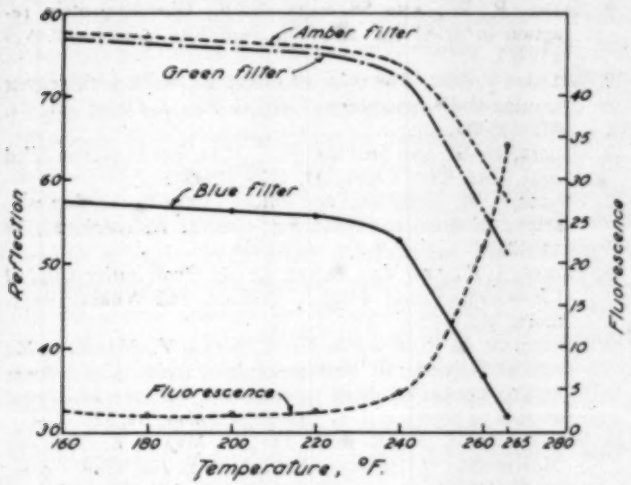

FIG. 2. Effect of temperature of heating on fluorescence and color of evaporated milk.

samples of evaporated milk were taken from a commercial plant just prior to sterilization and heated in a Fort Wayne pilot batch sterilizer to the temperatures indicated for 5 minutes. In order to accomplish the heating of milk at 250° F. or higher in a Fort Wayne sterilizer, the pressure valve was changed to allow for a pressure in the sterilizer up to 30 pounds. The "come up" time to reach the selected sterilization temperature was eleven-twelve minutes in all cases. The fluorescence and color were determined within 24 hours after heat treatment. Examination of Fig. 2 shows that the fluorescence and browning develop simultaneously and their formation proceeds at about the same rate as the temperature is raised. When the time of heating was 5 minutes, the changes did not occur until the temperature exceeded 240° F. (116.0° C.).

The effect of time and temperature of heating on the fluorescence is illustrated in Fig. 3 and the color and CO_2 production data on the same samples, are presented in Fig. 4. In Fig. 4 the color is expressed in the terms of the reflectance of the blue filter only since the reflectance data of green and amber filters were parallel to that of the blue filter. There are, as would be expected, marked increases in the rate of fluorescence formation as the temperature is raised. At 243° F. (117.5° C.) the rate is relatively slow during the first 10 minutes of heating. At 265° F. (129.5° C.) the rate is much faster and fairly uniform throughout the duration of heating. From the data of Figs. 3 and 4, it is apparent that the changes responsible for fluorescence, color, and CO_2 production are closely associated.

In dried egg powder *(21)*, dried banana, dehydrated pork, and other products *(2, 8)*, it has been shown that fluorescence can be used as an objective measure of palatability. The data presented in this study on the

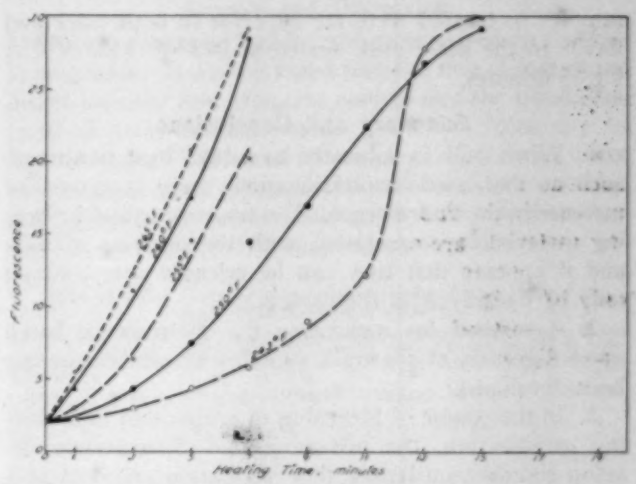

FIG. 3. Effect of time and temperature of heating on fluorescence of evaporated milk.

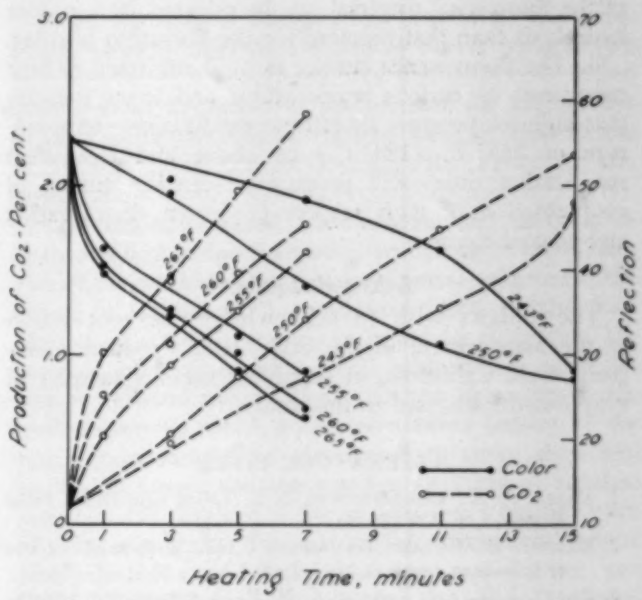

FIG. 4. Effect of time and temperature of heating on Co_2 production and color of evaporated milk.

relation between fluorescence and browning and those of Tarassuk *(18, 20)* on the relationship of browning to flavor of evaporated milk indicate that the fluorescence of the protein fraction of evaporated milk is a reliable index of the extent of deterioration in the quality. This being the case, it is evident from Fig. 3 that a high-temperature short-time sterilization process would greatly improve the quality of evaporated milk. From data available in the literature it would be safe to assume that a sterilization time of 5-7 minutes at 250° F. (121.0° C.) or approximately two minutes at 265° F. (129.5° C.) would render a product sterile. The exact time-temperature relationships have not been established at this time. It is apparent from Fig. 3 that the fluorescence formed, for example, by heating to 265° F. (129.5° C.) for 2 minutes is only a fraction of that formed by heating at 243° F. (117.5° C.) for 15 minutes. Actual color and flavor examination of the milk heated at 250° F. (121.0° C.) for 5 minutes or at 265° F. (129.5° C.) for 2 minutes indicated that the

samples so treated were far superior in both color and flavor to the same milk heated at 243° F. (117.5° C.) for 15 minutes.

Summary and Conclusions

1. When milk is subjected to a high heat treatment, such as that used for sterilization, there is a marked increase in the fluorescence. The fluorescing and browning materials are associated with the proteins of milk and it appears that they can be released into solution only by hydrolysis of the protein.

2. A method for measuring the fluorescence based upon digestion of the milk proteins by pancreatin has been developed.

3. In the course of browning of evaporated milk during sterilization, the browning and fluorescence develop simultaneously and their formation proceeds at a parallel rate. The data indicate that the browning and fluorescing materials are not necessarily identical. All of the fluorescing material can be released by a milder hydrolysis than that required for the liberation of color.

4. The fluorescence studies of milk subjected to heat treatments at various temperatures and times indicate that high-temperature short-time sterilization—temperature of 255° F. (124° C.) or above and equivalent sterilization time—will produce a superior quality of evaporated milk with respect to brown discoloration and cooked flavor.

Acknowledgment

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Rate of Destruction of Reduced Ascorbic Acid in Riboflavin-Fortified Pasteurized Milk[a]

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Additions of riboflavin to pasteurized milk did not increase rate of loss of reduced ascorbic acid when stored in the dark as shown by these experiments. Riboflavin was added in amounts of 0.0, 4.0, and 8.0 mg. per liter to 19 weekly samples of pasteurized milk. At the end of 96 hours storage at 10° C. in the dark, the samples had lost 77 percent, 73 percent, and 69 percent respectively, of the original amounts of reduced ascorbic acid.

It is generally concluded from the various American and European studies of the vitamin content of fresh commercial cows' milk that it contains 15 to 25 mg. of reduced ascorbic acid per liter and 1.5 to 2.0 mg. of

[a] Contribution No. 718, Massachusetts Agricultural Experiment Station.

riboflavin per liter. On the other hand, mares' milk contains about a tenth as much riboflavin and six to eight times as much reduced ascorbic acid as cows' milk. During a study of the stability of reduced ascorbic acid in cows' milk, Gunsalus and Hand *(1)* found that approximately 80 percent was lost during storage for six days. In contrast, Holmes and Jones *(2)* reported a loss of only 8 percent of reduced ascorbic acid from mares' milk during a similar storage period. These observations raised a question concerning whether the different ratios of reduced ascorbic acid to riboflavin in the two types of milk bore any relationship to the difference in the rate of loss of reduced ascorbic acid from mares' and cows' milk. Holmes *(3)* tested the effect of changing the ratio of reduced ascorbic acid to riboflavin by adding riboflavin to mares' milk and storing it under controlled conditions. The riboflavin was added at the rate of 2 mg. and 4 mg. per liter. During 96 hours' storage in darkness at 10° C., the two lots of riboflavin-enriched mares' milk lost reduced ascorbic acid at approximately the same rate and at a faster rate respectively than the control samples. However, at the end of the storage period, both lots of riboflavin-enriched mares' milk retained 85 percent of their original reduced ascorbic acid.

In this study riboflavin was added to pasteurized cows' milk to determine whether the presence of a larger amount of riboflavin would influence the rate of loss of reduced ascorbic acid.

Experimental Procedure

The milk used in this study was produced by a mixed herd of 70 purebred Ayrshire, Guernsey, Holstein, Jersey, and Shorthorn cows maintained under conditions similar to those of commercial dairy herds. The milk was pasteurized in commercial-size lots in stainless steel vats by the holding process at 143° F. for 30 minutes. Once a week for 19 weeks during the winter, a supply of pasteurized milk was taken to the laboratory as soon as it was thoroughly cool and there divided into three identical lots. U. S. P. riboflavin was added to one lot at the rate of 4 mg. per liter and to a second lot at the rate of 8 mg. per liter, while the third lot served as a control. They were stored in darkness at 10° C. for the next 96 hours. The three lots were assayed for reduced ascorbic acid as soon as they were prepared and at 24-hour intervals thereafter for the remainder of the period of observation. When aliquots were withdrawn for assay, the volume of air in the containers increased; thus the samples were held under a condition similar to that frequently found in homes where milk is stored for a time in partially filled bottles.

The amount of reduced ascorbic acid in the samples at various storage intervals was determined by a modification of the method recommended by Sharp *(5)*. Briefly stated, the procedure was as follows: 25 ml. of a solution of 8 percent of acetic acid and 3 percent metaphosphoric acid was added to 25 ml. of milk to precipitate the milk proteins. The mixture was diluted with 25 ml. of distilled water and titrated to a definite pink endpoint with a previously standardized solution of sodium 2, 6-dichlorobenzenoneindophenol.

Results and Discussion

The experimental results are summarized in the following table. It will be noted that the rate of loss of reduced ascorbic acid from the control and the riboflavin-fortified milk samples varied somewhat from day to day for each of the series of samples. Also, in all three series of samples, the rate of loss of reduced ascorbic acid was slightly greater during the first half than during the second half of the experimental period.

Effect of added riboflavin on retention of reduced ascorbic acid in milk stored in the dark at 10° C.

Added Riboflavin mg./l	Average Amount Reduced Ascorbic Acid Present, mg./l					% Loss
	0 Hours	24 Hours	48 Hours	72 Hours	96 Hours	96 Hours
0 (control)	15.0	10.3	6.9	4.8	3.5	77
4	15.0	11.0	7.6	5.1	4.1	73
8	15.0	10.4	7.0	5.4	4.6	69

Since the control samples lost somewhat more reduced ascorbic acid than either of the series enriched with riboflavin, it is apparent that the presence of added riboflavin in the milk did not increase the rate or the amount of destruction of reduced ascorbic acid in the milk under the conditions of storage that existed in this study.

The values obtained for the rate and amount of destruction of reduced ascorbic acid in the control samples discussed above are nearly identical with those obtained by Holmes *(4)* for pasteurized milk control samples in a previous study conducted to determine the possible effect of enriching milk with lactose upon the loss of reduced ascorbic acid. In the latter study, the control samples were stored, at another season of the year, under conditions identical with those employed in this instance; and the average amounts of reduced ascorbic acid obtained at the various assay periods were 14.7 mg. per liter at the start and at subsequent 24-hour intervals, 8.6 mg., 5.5 mg., 4.4 mg., and 3.8 mg. per liter. Thus the rate and amount of loss of reduced ascorbic acid from untreated pasteurized milk stored in darkness at 10° C. were nearly the same in the two experiments.

Summary

According to these data, increasing the amount of riboflavin in pasteurized milk did not increase the rate of loss of reduced ascorbic acid from the milk which was stored in the dark at 10° C.

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Value of Starch Coating in the Preservation of Quality of Dehydrated Carrots

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The storage life of diced dehydrated Imperator carrots at 84°F., sealed in Cellophane, was increased four- to six-fold by a coating of hot 2.5 percent corn starch sprayed on the hot blanched dice before drying. Evidence of this protective effect was shown over a period of nine months by large differences in carotene retention, color reflectance in the dry state, and by color and flavor judgments in the cooked state. Results also indicated that sulfiting was of little if any value, and that packing in well-filled hermetically sealed cans increased the 84°F. storage life of blanched and blanched-sulfited samples by only a few weeks.

Introduction

The use of starch as a coating to protect dehydrated carrots from deterioration during storage was originally suggested by work from the Western Regional Research Laboratory in 1943 *(4)*. Because of the exigencies of wartime research it was not followed up at that time. Tomkins, Mapson, and Wager published *(5)* on the value of starch-coating carrots for dehydration in 1946 and received a British patent on the process in 1948 *(6)*. Recently, Weier and Stocking *(7)* reported on the influence of various antioxidants on dehydrated carrots. They found some treatments effective in retarding pigment breakdown in ground material, but none effective on the whole dice.

In response to a request from industry for further research information on the use of starch coating for dehydrated carrots, work was initiated here early in 1948. Starch coating of the whole dice was considered a promising alternative method of treatment to the prevalent commercial practice of sulfiting carrots for drying. Some disadvantages of the latter are: maintenance of quality in sulfited dehydrated carrots at unrefrigerated temperatures requires gas packing in tin containers, adding to expense; there is consumer reluctance to the purchase of some sulfited products; and, most critical, there are legal restrictions against the sale of sulfited food products in several states.

The primary object of the project was to develop a coating for dehydrated carrot dice which would prevent or retard discoloration—chiefly loss of the characteristic orange-red color—without sulfiting and without the use of gas packing and tin containers. After some preliminary experiments, an experimental pack was designed to test the efficacy of starch for such a purpose. The carrots were processed with the cooperation of California Vegetable Concentrates, Inc., and the use of the facilities of their Modesto, California, plant. The raw material was a single lot of mature Imperator carrots, and all processing was carried out in the course of one day. The carrots were washed, lye-peeled, cut to $\frac{3}{8} \times \frac{3}{8} \times \frac{1}{16}$ inch dice, processed as given below, dried to 6-5 percent moisture,[b] and brought to the Laboratory for packaging, storage, and evaluation. The four different processing methods gave (1) an unblanched lot, (2) a lot blanched 6 minutes in steam at 210° F., (3) a regular commercial lot similarly blanched and sulfited to 464 p.p.m. sulfur dioxide in the dried product, and (4) a lot blanched 6 minutes in steam immediately followed with a thorough spray application of 2.5 percent corn starch at 175° F.[c] Each lot was subdivided for packaging, (1) in tin in nitrogen, (2) tin in air, and (3) in Cellophane bags[d] in frozen-food cartons. The nitrogen-packed carrots were stored at —30° F. as controls, and the air- and Cellophane-packed at 84° F. for accelerated storage and simulation of summer market temperatures. Storage evaluations of all samples for carotene content, color reflectance in the dry state, and for color and flavor in the cooked state by panel appraisal, were made at 0, 1, 3, 6, and 9 months. Reference to the evaluation methods used accompanies presentation of the data, which follow.

Data Obtained

Figure 1 shows the loss of carotene with storage in Cellophane at 84° F. Carotene was determined in duplicate by a modification of the A. O. A. C. method *(1)*. The modification was necessary to effect complete extraction of the carotene from dried carrot.[e] The chromatographic portion of the A. O. A. C. procedure was not changed. Table 1 gives the numerical values for loss of carotene. These percentages and the curves in Figure 1 shows four points very clearly: (1) that the control sample remains constant within the limits of sampling and analytical variability, (2) that the unblanched sample, as was to be expected, lost carotene very rapidly, with a half-life at about 1 month, (3) that

[a] Bureau of Agricultural and Industrial Chemistry, Agricultural Research Administration, U. S. Department of Agriculture. Presented before the Ninth Annual I. F. T. Convention, San Francisco, Calif., July 13, 1949.

[b] Forty-mesh grind dried 40 hours *in vacuo* at 60° C. (140° F.).

[c] The hot blanched dice were taken from the blancher and dropped slowly by hand through a foot-square box holding four pressure spray nozzles. The hot starch solution was pumped through these nozzles by a centrifugal pump. The nozzles were arranged in two opposed pairs, with the line of the pairs 90° apart, and approximately one foot apart vertically. The box holding the nozzles was supported over the drying trays to catch the dice as they dropped and to allow for drainage of excess starch solution. The drainage was appreciable, indicating that at least superficial saturation had occurred. The dice were spread uniformly over the trays before they were placed in the drying-tunnel trucks.

[d] Moisture-resistant, transparent, anchor-coated, 450 gauge.

[e] G. S. Bohart, to be published.

TABLE 1

Loss of Carotene in Dehydrated Carrots Stored in Cellophane at 84° F., Expressed as Percentages of Initial Content

Processing Treatment	Storage period, months				
	0[a]	1	3	6	9
	p.p.m.				
Unblanched	1047	52.1	85.8	91.8	93.9
Blanched only	1265	34.2	60.1	70.2	77.4
Blanched and sulfited	1290	32.8	58.8	74.5	81.9
Blanched and starch sprayed	1292	15.0	28.4	36.4	50.1
Control[b]	1290	2.5	6.4	2.7	1.0

[a] Initial carotene content (p.p.m.).
[b] Blanched and sulfited sample, stored in N_2 at —30° F.

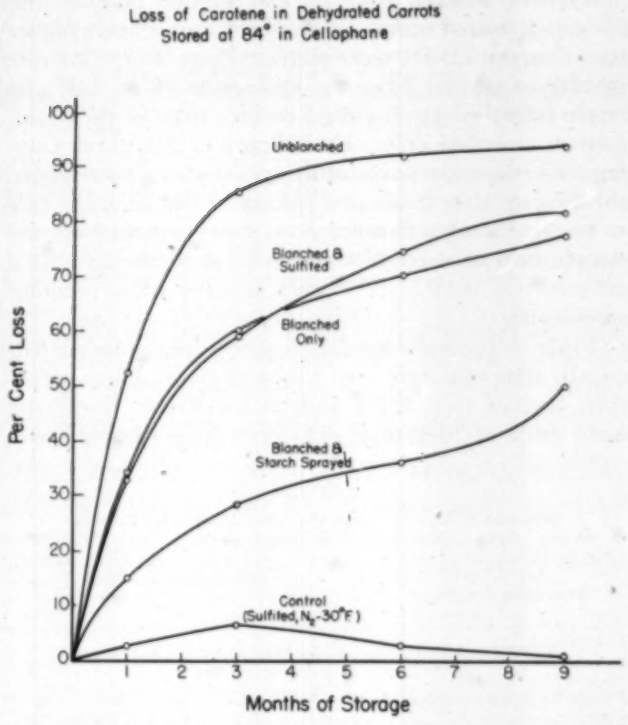

FIG. 1. Loss of Carotene in Dehydrated Carrots Stored at 84° in Cellophane.

the blanched and blanched-sulfited samples behaved alike, losing much less carotene than the unblanched lot, and with a half-life at about 2 months, and (4) that the starch-coated sample was much superior in carotene retention to both blanched and sulfited samples, with a half-life at 9 months.[f] With these approximate points of half-life as indices for comparison, it can be stated that blanching alone or blanching plus sulfiting was twice as effective as no blanching, and that starch coating was nine times as effective as no blanching, or four and one-half times as effective as either blanching or blanching plus sulfiting. This protection afforded by starch coating is of a surprising magnitude.

Table 2 shows the loss of carotene with storage in sealed cans at 84° F. These values compared to Table 1 (cellophane packing) show the benefits of packing in air in cans for other than the starch-coated carrots. Carotene losses from 3 months' storage on were significantly reduced by this method of packing in the unblanched, blanched, and sulfited samples. Differences

[f] Carotene analysis of the starch-coated sample showed 50 percent retention at 12 months' storage (cellophane, 84° F.).

TABLE 2

Loss in Carotene in Dehydrated Carrots Stored in Air in Cans at 84° F., Expressed as Percentages of Initial Content

Processing Treatment	Storage period, months				
	0[i]	1	3	6	9
	p.p.m.				
Unblanched	1047	30.8	42.5	47.1	54.3
Blanched only	1265	28.4	41.2	52.5	59.8
Blanched and sulfited	1290	29.2	49.2	62.9	58.6
Blanched and starch-sprayed	1292	14.5	28.8	31.7	40.2
Control[j]	1290	2.5	6.4	2.7	1.0

[i] Initial carotene content (p.p.m.).
[j] Blanched and sulfited sample stored in N_2 at —30° F.

in favor of tin packing were greatest in the unblanched, less in the blanched, least but still significant in the sulfited, and none in the case of the starch-coated sample except at 9 months' storage, which showed a carotene difference of 10 percent in favor of tin packing. Comparison of carotene retention in starch-coated samples stored in cellophane with blanched or sulfited carrots in tin greatly favored the starch-coated carrots up to 6 months' storage at 84° F. and slightly so even at 9 months. Half-life of the tin-packed sulfited samples was 3 months, for example, as compared to 9 months for the starch-coated sample in cellophane, thus demonstrating again the high degree of protection afforded by starch.

Table 3 and Figure 2 show loss of color with storage in cellophane at 84° F. in terms of decreasing "yellow-

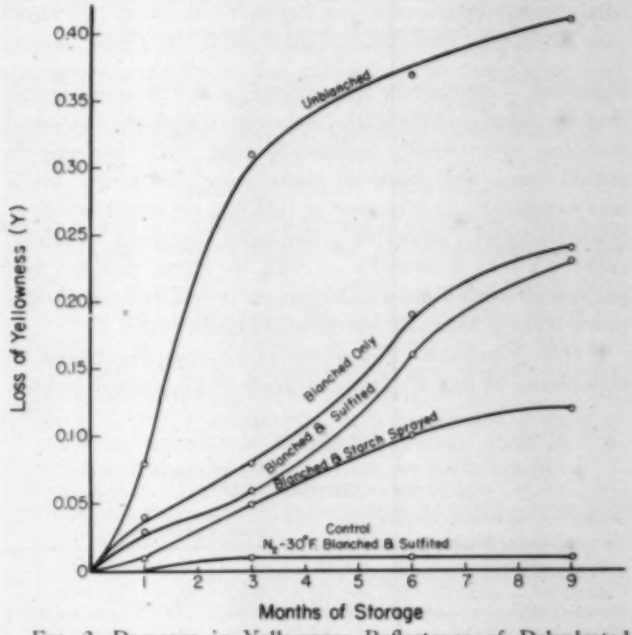

FIG. 2. Decrease in Yellowness Reflectance of Dehydrated Carrots Stored at 84° F. in Cellophane.

TABLE 3

Loss of Yellowness ("Y") in Dehydrated Carrots Stored in Cellophane at 84° F., Expressed as Differences from Initial Values for Reflectance Measurements

Processing Treatment	Storage period, months				
	0[k]	1	3	6	9
Unblanched	1.00	0.08	0.31	0.37	0.41
Blanched only	1.32	0.04	0.08	0.19	0.24
Blanched and sulfited	1.31	0.03	0.06	0.16	0.23
Blanched and starch sprayed	1.35	0.01	0.05	0.10	0.12
Control[l]	1.31	0.00	0.01	0.02	0.01

[k] Initial "Y" value.
[l] Blanched and sulfited sample, stored in N_2 at —30° F.

ness" *(2)*.[m] In this instance a decreasing yellowness index means progression from red, through orange and yellow, toward white. It was measured on the dried product with a Hunter Multipurpose Reflectometer. These values designated as "Y" are subject to a sampling and measurement variability of ±0.01. Percentagewise, at 9 months for example, yellowness values decreased 41 percent in the unblanched sample, 18 percent in blanched and in sulfited samples, and only 9 percent in the starch-coated samples. Except for those between blanched and sulfited samples, differences are obviously significant, and further emphasize the value of starch coating.

Table 4 shows the same color-loss measurements with storage in sealed cans at 84° F. At 9 months the percentagewise decreases in yellowness were all small—9 percent in the unblanched sample, 7 percent in the blanched, 3 percent in the sulfited, and 7 percent in the starch-coated. Differences between the three blanched samples were small, indicating that with packing in sealed cans, well filled as these were, blanching alone was practically as effective as sulfiting or starch coating. Starch-coated carrots in cellophane, however, retained color (Y) at 6 months as well as those sulfited and packed in sealed cans. Decreases in yellowness at this point were practically identical (Tables 3 and 4).

TABLE 4

Loss of Yellowness ("Y") in Dehydrated Carrots Stored in Air in Cans at 84° F., Expressed as Differences from Initial Values for Reflectance Measurements

Processing Treatment	Storage period, months				
	0[n]	1	3	6	9
Unblanched	1.00	0.03	0.10	0.09	0.09
Blanched only	1.32	0.03	0.06	0.10	0.09
Blanched and sulfited	1.31	0.03	0.03	0.09	0.04
Blanched and starch sprayed	1.35	0.04	0.03	0.07	0.09
Control[o]	1.31	0.00	0.01	0.01	0.01

[n] Initial "Y" value.
[o] Blanched and sulfited sample, stored in nitrogen at —30° F.

Table 5 presents flavor scores of samples stored in cellophane at 84° F., from a panel of 12 trained judges.

TABLE 5

Appraisal Scores for Flavor of Cooked Dehydrated Carrots Stored in Cellophane at 84° F.

Processing Treatment	Storage period, months				
	0	1	3	6	9
Unblanched	3.3	2.4	1.5[p]	....	....
Blanched only	5.4	5.0	4.8	3.1	3.3
Blanched and sulfited	4.6	5.0	4.7	3.3	3.2
Blanched and starch sprayed	5.1	5.2	4.7	4.3	4.6
Control[q]	5.6	5.5	5.9	4.5	5.1
Least significant difference[r]	0.6	0.4	0.6	0.5	0.4

[p] Samples not appraised after this examination because of highly objectionable flavor.
[q] Sample blanched only and stored in N_2 at —30° F.
[r] Calculated at the 5% level.

Estimates were made of "degree of flavor difference from good natural carrot flavor" on a scale ranging from 1 for "much" difference, to 7 for "none." Samples were riced and dyed to avoid prejudices due to texture and color.[s] Each judgment was replicated 5 times. Interpretation of data is based on analysis of variance of the five mean scores. The flavor of the unblanched samples became so objectionable at 3 months' storage that it was dropped at that time. The other three processed samples showed no appreciable differences up to 3 months, except from the control, thus indicating that starch coating or sulfiting did not result in any improvement over blanching alone up to this point. At 6 and 9 months' storage there were still no significant differences between blanched and sulfited samples, but the starch-coated sample was judged significantly higher than these by 1.0-1.4 score points. These scores indicate that flavor beyond 3 months' storage at 84° F. holds up much better in starch-coated carrots than in those sulfited or blanched only. The efficacy of the starch coating with respect to flavor at this point seems remarkable, showing up after 6 months' storage at 84° F., in a score of no significant difference from the N_2-packed control sample held at —30° F.; and even at 9 months with a difference of but 0.5 score point, which is of no practical significance.

Table 6 presents appraisal scores for color in the cooked state obtained from the same panel, but on separate samples from those judged for flavor. Estimates were made of "degree of difference from natural carrot color" on a scale ranging from 1 for "much" difference to 7 for "none." The unblanched sample lost color very rapidly with storage. At 1 month, samples showed a small but a significantly higher score between treatments of about 0.5 score point in the following order (from large to small): control, starch-coated, sulfited, and blanched only. At 3, 6, and 9 months there was no significant difference between blanched and sulfited samples, but the scores of both decreased progressively to 4 full points less than the control, thus indicating considerable loss of color. During the same period the starch-coated sample decreased but 2 points below the control; thus the starch afforded considerably more color protection than blanching alone or sulfiting. Compared another way, the color of blanched and sulfited

TABLE 6

Appraisal Scores for Color of Cooked Dehydrated Carrots Stored in Cellophane at 84° F.

Processing Treatment	Storage period, months				
	0	1	3	6	9
Unblanched	4.3	1.9	1.4[t]	....	....
Blanched only	6.2	4.9	4.2	3.5	2.7
Blanched and sulfited	6.2	5.3	3.8	3.3	2.4
Blanched and starch sprayed	6.4	6.0	5.6	5.3	4.6
Control[u]	6.5	6.5	6.9	6.7	6.7
Least significant difference[v]	0.3	0.2	0.4	0.3	0.5

[t] Samples not appraised after this examination because of highly objectionable flavor and very poor color.
[u] Sample blanched only and stored in N_2 at —30° F.
[v] Least difference between any two means that is significant at P = .05 level.

[m] "Y," used here to designate yellowness, should not be confused with the ordinary usage of this symbol to indicate luminous reflectance.

[s] Cooking method was as follows: 40 g. carrot into 450 ml. boiling water; boiled in covered container 20 minutes, except unblanched, which were boiled 25 minutes. Red and blue dye in small amounts was added to each sample after ricing cooked samples.

samples at 1 and 3 months' storage showed as much deterioration as the starch-coated samples at 9 months.

Summary and Conclusions

Table 7 presents data from the 6 months' storage examination of the 84° F. cellophane pack for all four quality evaluations. Values given express deteriorative changes compared to the control sample—the larger the figure, the greater the deterioration. Support from these evaluations for the value of starch coating, and lack of value of sulfiting, is self-evident. Agreement between

TABLE 7

Quality Deterioration in Dehydrated Carrots as Compared to Control, at 6 Months' Storage in Cellophane, 84° F.

Processing Treatment	Percent Carotene	Reflectance "Y"	Appraisal score	
			Color	Flavor
Unblanched	—91.8	—0.37	—5.5	—4.4 *
Blanched only	—70.2	—0.19	—3.2	—1.4
Blanched and sulfited	—74.5	—0.16	—3.4	—1.2
Blanched and starch sprayed	—36.4	—0.10	—1.4	—0.2

* Three months' storage values—samples not appraised at later storage periods because of highly objectionable quality at this examination.

these diverse types of quality evaluations for each processing variable is remarkably consistent, as shown by the high correlation coefficients between quality evaluation methods (Table 8). The correlation between loss of carotene and color score for the cooked carrots (0.961) indicates that 92 percent of the variance in color, as measured by the appraisal panel, could be accounted for by differences in carotene loss. Such a high degree of correlation indicates that loss of either

TABLE 8

Correlation Coefficients Between Quality Evaluation Methods, 6 Months' Storage, Cellophane, 84° F.

	Correlation coefficient	Standard error of estimate
Carotene Loss vs.		
Reflectance, "Y" (dry)	0.822	±0.081 [x]
Flavor score (cooked)	0.854	±1.16 [y]
Color score (cooked)	0.961	±0.57 [z]
Reflectance, "Y" (dry) vs.		
Color score (cooked)	0.850	±1.08 [z]

[x] In terms of reflectance loss.
[y] In terms of flavor score.
[z] In terms of color score.

carotene or appraisal score for color could be predicted from the other with considerable accuracy. The other correlations indicate that two-thirds to three-fourths of the variance in one measurement could be accounted for by differences in the other.

In connection with the negative results of sulfiting in this study, it should be noted that moisture content, sulfite level, and storage temperature were all considerably lower than reported for dehydrated carrots in the study of the browning reaction by Legault and others *(3)*. The lower storage temperature is particularly important in this respect. At higher moisture and storage temperature, especially for prolonged periods, sulfiting can be employed if browning is likely to occur.

The results of the study, both individually and collectively, support the following conclusions without exception:

(1) That with carrots dried to the 5-6 percent moisture level and packed in cellophane, blanching alone is an effective means of reducing quality deterioration during storage at 84° F. for periods of only a few weeks.

(2) Under the conditions of this study, the addition of sulfite after the blanch gave no more stability to the product than blanching alone.

(3) Packing the blanched or the blanched and sulfited product in well-filled hermetically sealed cans increases the 84° F. storage life by approximately 100 percent over packing in cellophane.

(4) The use of a starch coating, applied following the blanch, increases the 84° F. storage life of dehydrated carrots packed in cellophane by 400 to 600 percent.

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Quality Problems in Cooked, Frozen Potatoes[a]

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Cooked potato could be frozen successfully provided rate of freezing was fast enough. "Cottoniness," a texture that feels like moist cotton in the mouth, was avoided when a temperature of 32°F. was reached in less than 5 minutes and 25°F. (—4°C.) in less than 8 minutes. Samples of successfully frozen cooked potato kept well at 0°F. and —12°F. (—24.5°C.) during the 2-month test period.

Cooked potatoes, with the possible exception of French-fries, have a reputation of "not freezing well." They assume an undesirable texture, a fact which often prevents people from including them in combination dishes to be frozen. Fenton and Darfler *(3)* in a discussion on combination dishes for the freezer, state that potatoes apparently freeze least well.

One of the most undesirable changes in texture of frozen cooked potatoes may be described as "cottoniness." The term, as understood by the writer and used in this study, refers to a texture that seems to be dry and wet at the same time. An extremely cottony sample feels like wet cotton in the mouth. Cottoniness should not be confused with textural changes of a different nature, such as dryness, due to lack of moisture, or with mushiness or sliminess.

The problem of cottoniness has been puzzling. In preliminary tests under ordinary conditions of home freezing all samples were extremely cottony upon thawing. Reheating of slowly frozen samples had a profound effect upon texture. It did not, however, always completely restore good texture. The conditions under which the samples were reheated seemed to deserve study. Little was found in the literature on the effect of freezing on cooked potatoes.

The purpose of the present investigation was to shed light on the following problems: (1) the nature of cottoniness, (2) the factors possibly leading to cottoniness, (3) the effect of conditions of reheating on texture of frozen cottony potato tissue, (4) how cottoniness could be avoided so as to eliminate the necessity of reheating. Knowing ways to prevent cottoniness altogether would enable one to freeze dishes, involving cooked potatoes, that are commonly served and eaten cold, such as potato salad.

Because of the high starch content of potato tissue, the behavior of starch during and after freezing is of interest and was thought to be of possible importance. Although considerable work has been done on the effect of heating on potato starch, especially in relation to culinary quality of potatoes *(1)*, no reports were found on the effect of freezing on gels made from potato starch.

From work done with wheat and cornstarch gels it is known, however, that the process of freezing involves certain changes in the texture of the gels. Freezing tends to result in retrogradation of the starch pastes. During retrogradation the water-holding capacity of the starch decreases and more or less "leakage" occurs. Starch gels, thus partially dehydrated, may assume a spongy texture. Holton *(6)*, working with wheat starches, produced retrogradation by freezing a starch-water gel at 3° C. Woodruff and Hayden *(16)* made similar studies on wheat and corn starch with comparable results. They found that the temperatures at which the gels were allowed to freeze had a great effect on "sponginess" of resulting product. MacMasters et al. *(9)* in studying the effect of freezing on sols or pastes of starch, waxy starch, and amylopectin, found that all formed spongy masses upon slow freezing and thawing.

In the present investigation the effect of freezing on cooked potato tissue was studied. The starch was "tested" and observed while still enclosed within the cells of the tissue rather than in prepared gels. This fact may have made the problem somewhat complex. On the other hand, it was hoped by this method to eliminate errors which may be incurred when one tries to create "normal" conditions outside of cells. Possible errors may result from conditions of relative moisture, or the possible presence of electrolytes. Also, the study was concerned with problems of texture of the potato as a whole, and therefore the effect of various treatments on the tissue as a whole seemed of importance.

Experimentation

Materials and Procedures. California white potatoes were used in all experiments. For comparable studies only tubers of the same "lot" were used. These "lots," however, were bought on the market and were of unknown origin. The potatoes were brought to the laboratory, washed, and allowed to remain at room temperature for at least three days before they were used. In order to avoid great variation in mealiness, the tubers were roughly grouped into four classes on the basis of their specific gravity *(10)*. Tubers that were of a specific gravity of 1.062 or below were grouped in Class 1. Those of specific gravity between 1.062 and 1.078 fell in Class 2. Those of specific gravity between 1.078 and 1.090 formed Class 3. All those of a specific gravity higher than 1.090 made up Class 4.

All potatoes were boiled in the skin, unless otherwise stated. The tubers were cooked to an internal temperature of 97.8° C. *(13)*, peeled, and the outer cells, the true cortex, scraped off. From then on the treatment varied according to the treatment the tubers were to

[a] This study was made possible through a grant made by the Committee on Faculty Research of Hampton Institute, Hampton, Virginia. The experimental work was done at the N. Y. State College of Home Economics, Ithaca, New York. The author wishes to express her thanks to Dr. Faith Fenton for granting her the privilege of using the laboratory facilities, to Mrs. Ella Gleim Andreassen for her untiring co-operation, and to the panel of judges of Dr. Fenton's laboratory. Since for some experiments the facilities of the School of Nutrition at Cornell University was used, the author wishes to extend her appreciation to Dr. W. A. Gortner, Dr. W. L. Nelson, and to Miss Frances Volz.

undergo. For certain tests it was desirable to separate the tubers into cortex, outer medulla, and inner medulla *(14)*. Wrapping material was aluminum foil, in most instances; for larger samples, half-pint glass jars or half-pint parafined cartons were used. Details of the procedure in each case precedes the description of the individual experiments.

Palatability Tests. The samples were scored for cottoniness by a panel of five trained judges, all women. The lots were coded and the judges did not know the history of the samples. Perfect texture was designated as 100; excellent as 80; good (average) as 60; fair (slightly cottony) as 40; poor (definitely cottony) as 20; inedible (very cottony) as 0. The total score on texture (cottoniness) for a sample was arrived at by averaging scores by each judge.

Microscopic Studies on Potato Tissues Showing Varying Degrees of Cottoniness. In order to find a method of testing for the presence or absence of cottoniness which would be more objective than palatability tests, Friess's *(4)* method of crystallographically detecting changes in biological material (changes that are brought about by heating, freezing, etc.) was tried first. It was found, however, that Friess's method did not reveal differences between samples showing different degrees of cottoniness and that it is, therefore, not suitable for the detection of cottoniness in cooked, frozen potatoes.

Effect of Freezing on Cell Size and Cell Content. Examination for possible changes in cell size and cell content were made on cells taken from tubers of different specific gravity (mealiness) before freezing and after slow freezing and after thawing. The cells were mounted in distilled water; it did not seem to make any difference whether distilled water or juice extracted from raw potato was used (Table 2). Samples were taken from three soggy tubers of low specific gravity (Class 2) and of three mealy tubers of high specific gravity (Class 4) of the same lot of potatoes. Twenty measurements of cell size (length and width) were made in each case. After the measurements and other observations had been made, the glass slides were warmed over a low flame until the water began to simmer. The cells were then measured again (Table 1).

Freshly cooked, unfrozen potato tissue was characterized by cells packed with swollen starch granules whose delicate outlines allowed the cell content to appear more or less smooth (Fig. 1a). With different conditions of freezing, the cell content changed. With slower freezing, fine to coarse strands were noticed, giving the cell content a reticulated appearance (Fig. 1c). In very cottony samples the starch granules had shrunk away from the cell walls. The cells had also changed in shape. They appeared more irregular and more angular in outline. The changes were from slight to pronounced (Fig. 1e). No significant differences between tubers of different specific gravity appeared.

TABLE 1

Comparative Size of Potato (Cooked) Cells: Unfrozen; Frozen Slowly, Then Thawed; Slowly-Frozen, Then Reheated to Boiling [b]

Mealiness	Part of Tuber	Average Size of Cells in μ		
		Freshly cooked, unfrozen	Cooked, then frozen	Cooked, frozen, then reheated in water
Soggy tubers	Cortex	202 x 157	146 x 139	257 x 210
	Outer medulla	222 x 175	174 x 127	258 x 203
	Inner medulla	217 x 167	169 x 127	258 x 202
	Average	214 x 166	163 x 131	258 x 205
Mealy tubers	Cortex	202 x 166	175 x 131	234 x 184
	Outer medulla	205 x 159	168 x 140	235 x 195
	Inner medulla	200 x 159	177 x 131	245 x 188
	Average	203 x 161	173 x 134	238 x 189

[b] Average of two experiments.

TABLE 2

Effect of Distilled Water and of Boiled Juice Extracted From Raw Potato on Reswelling of Frozen, Cooked Potato Cells During Reheating to the Boiling Point [c]

Part of Potato	Average Size of Cells in μ			
	Just thawed	Reheated in Water	Just thawed	Reheated in potato juice
Cortex	207 x 151	263 x 203	202 x 151	248 x 218
Outer medulla	210 x 141	281 x 218	180 x 122	248 x 195
Inner medulla	189 x 140	272 x 209	171 x 130	263 x 241
Average	202 x 144	272 x 210	184 x 134	253 x 218

[c] Average of two experiments.

It seems questionable whether measurements on cell size give more than a suggestion of the nature of cottoniness. Certainly cells in cottony samples show shrinkage and this shrinkage is probably related to the extent of shrinkage of the cell content, the gelatinized starch granules.

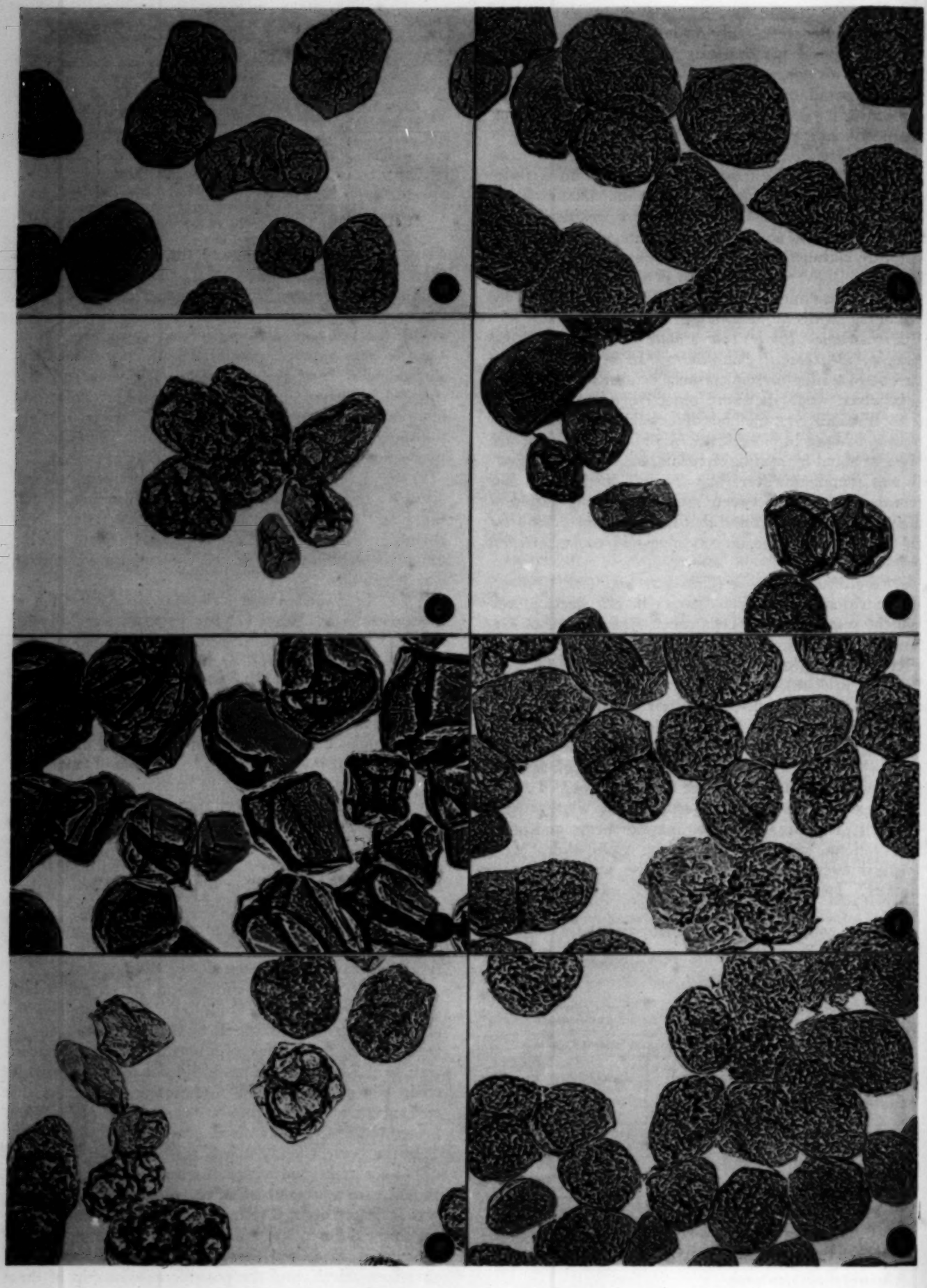
Effect of Thawing and Reheating on Reswelling of Shrunken Cells. When cottony potatoes were allowed to stand at room temperature until they began to spoil (for two or three days), or in a refrigerator at 42 to 45° F. (5.5 to 7.0° C.) for 14 days, no reabsorption of the water that had "frozen out" of the cells and starch granules during the freezing process took place. To some samples distilled water had been added in order to make sure that there was enough water readily available.

Schoch and French *(12)*, in studying retrogradation phenomena in starch pastes during aging, noted that heating to 100° C. effected a return of the gel to a soft, glutinous state.

Woodruff and Hayden *(16)* working with gels containing 5 percent by weight of corn or of wheat starch, found that gels which had retrograded during freezing would, upon "warming," produce a gel similar in appearance to the original one; the spongy masses, typical of starch gels frozen slowly, disappeared.

Holton *(6)*, working with wheat starch gels which she had allowed to retrograde by freezing, studied the ability of retrograded starch to reabsorb water and to reassume the appearance of a normal gel. In a concentration of 7 percent the paste did not form a gel while cold. When heated to 55° C. however, a paste of this concentration turned into a "shapeless" gel. When heated to 95° C. a gel with no syneresis resulted.

In the present sutdy it was reasoned that, if cottoniness were associated with retrogradation of starch, heat should have a pronounced effect upon cottony tissue. It was therefore decided to investigate the conditions leading to the different cell pictures: cells containing slightly reticulated starch and those characterized by extremely shrunken starch, and the possible relationship of these



cell pictures to cottoniness as determined in palatability test. The effect of heating on reswelling of cells of cottony potatoes was studied by reheating samples to different temperatures. The potatoes were frozen at —12° F. (—24.5° C.), then thawed and divided into 5-gram lots. These were wrapped in aluminum foil pieces of uniform size. The samples were reheated in a well insulated, electrically controlled oven with a rotating hearth, set at a temperature of 250° F. (120° C.).

A thermometer was inserted into the center of each sample. The first sample was removed for testing when the temperature reached 105° F. (41° C.), the second at 110° F. (43° C.) and the remainder at 5-minute intervals until no cottoniness could be detected. No cottoniness was detected above 135° F. (57° C.). The experiment was run three times.

In order to follow the cell picture during this process of "recovery," a heating stage was attached to the microscope. It was also hoped to determine more accurately the exact temperature at which this recovery process takes place. The hot stage was built by members of the Department of Electrical Engineering [e] following the general description laid down by Briant,[f] but improved and simplified (Fig. 2).

The aim of the following experiment was to find out at what temperature extremely wrinkled frozen cells reswell in water. A 100-gram sample of cooked, frozen potato tissue (outer medulla) was used. The sample had been frozen at —10° F. (—23.5° C.) and stored for three days at the same tmeperature. The cells were extremely wrinkled, similar to those reproduced in Fig. 1e.

At 123° F. (50.5° C.) some cells began to change. The sharp edges commenced to round out, and the cells took on a filled-out appearance. There was a general stretching and pushing. The majority of these shrunken cells "filled out" at a temperature of 132° F. (55.5° C.). Others needed higher temperatures. The last ones completed swelling at 133° F. (56° C.). Fig. 1f shows the same cells as Fig. 1e after these had been reheated to 133° F. (56°C.). Reticulated cells lost their net-like appearance at the same temperatures (Figs. 1g and 1h).

[e] Credit is due to Mr. J. C. Logue and to Mr. M. W. Morehouse of the Department of Electrical Engineering, Cornell University, for the construction of the instrument.

[f] Oral communication and thesis: Briant, Alice, "Some Physical Properties of Potato Starch," New York State College of Home Economics at Cornell University, 1940.

FIG. 1 (opposite page). Magnification of all pictures: 85 x

a. Starch-containing cells of freshly boiled, unfrozen potato. Outer medulla. Texture: smooth.

b. Starch-containing cells of quickly-frozen sample. Outer medulla and cortex mixed. Texture: smooth.

c. Starch-containing cells showing reticulation. Freezing rates slower than that used for 1b. Outer medulla. Texture: smooth.

d. Starch-containing cells; some not visibly changed; some reticulated; some shrunken.[d] Outer medulla. Texture: slightly cottony.

e. Starch-containing cells of slowly-frozen sample. Outer medulla. Texture: very cottony.

f. Starch-containing cells of slowly-frozen, cottony sample which has been reheated to 56° C. (133° F.) (same cells as 1e). Texture: smooth.

g. Starch-containing reticulated and shrunken cells before reheating. Outer medulla. Texture: slightly cottony.

h. Same cells as 1g, after reheating to 56° C. (133° F.) Texture: smooth.

[d] Freezing rate lower than that used for 1c.

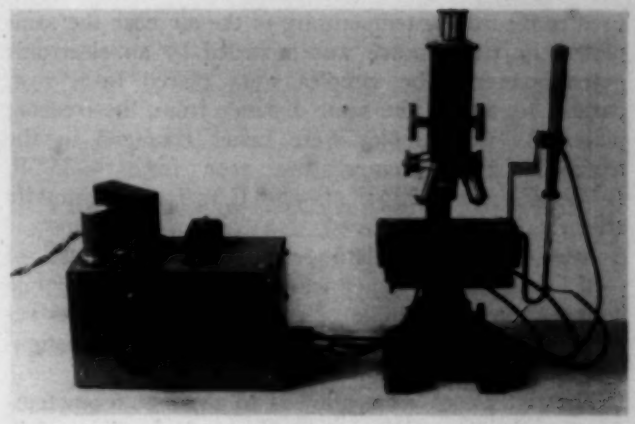


FIG. 2. Heating stage used in the microscopic study of frozen cells during the process of reheating after thawing. See text for description.

The experiment was repeated with steam as the only source of moisture. It was just as effective as water.

Thus temperatures of 123° F. (50.5° C.) were necessary to initiate the reswelling of starch contained in the cells of frozen, cottony potato tissue. Reswelling was completed at 133° F. (56° C.). Potatoes thus reheated had also lost cottoniness as felt by the tongue in palatability test.

Effect of Freezing Rates on Cottoniness. Woodroof *(15)* states that slow freezing rates are satisfactory for starchy vegetables. Lee, Gortner, and Whitcombe *(7)* in testing the effect of freezing rates on the eating quality, appearance, and vitamin values of peas and snap beans compared freezing rates (covering a very wide range) which were much faster as well as much slower than those used under commercial conditions or in individual freezing lockers. Although the freezing rates had a pronounced effect on the appearance of the tissues by favoring the formation of large crystals and partially shrinking and dehydrating the solids, thawing caused the fluids to be reabsorbed by the tissues so that they reassumed their natural appearance. Woodruff and Hayden *(16)* studied the effect of fast and slow freezing on 5 percent gels of corn and wheat starches. Fast freezing was achieved by the use of solid carbon dioxide. For slow freezing, temperatures of 28.5° F. to 26.5° F. (—2° C. to —3° C.) were used. When freezing took place at a low temperature, the gels retained most of their pasty appearance and little retrogradation was noted.

In the study reported herein, the freezing velocities were varied first by use of different size samples. Three tubers of California white potatoes of high specific gravity (Class 4, see page 98) and of similar weight (161.5, 162 and 163 grams) were boiled to doneness, then peeled. The portions coming from the outer medulla were mashed and mixed together. Samples of 2, 4, 8, 12, 16, and 32 grams in duplicate were then weighed out and shaped into balls and wrapped in small rectangular pieces of aluminum foil (druggist wrap). The ends of the foil were twisted, whereupon the sample assumed a somewhat cylindrical shape.

The freezer was set at —35° F. (—37° C.). Thermocouples were inserted in the center of one sample of each weight class. An extra pair of thermocouples was

used to record the temperature of the air near the samples. The temperature was recorded by an electronic potentiometer. The samples were placed in a row, parallel to, and at the same distance from, the freezing plate. As the samples were being arranged in the freezer, the air temperature rose from —35° F. (—37° C.) to —20° F. (—29° C.), but fell rapidly after the freezer was closed.

After all samples had reached a temperature of —35° F. (—37° C.) they were left undisturbed for one hour. Then one sample of each weight class was removed. The others were left in the freezer for investigation after two months of storage.

The test pieces were allowed to thaw at room temperature in the original wrappings of aluminum foil. Then they were opened, each sample was broken in two, and from the center a small sample of tissue was removed, allowed to thaw, placed in a drop of distilled water, and studied under the microscope. Three slides were prepared from each frozen sample. The remaining pieces were tasted for cottoniness.

The small samples froze extremely fast (Table 3), the recording potentiometer seemingly did not print sufficiently fast. Since interpolation may lead to gross errors, it is only possible to give the freezing time in approximate values.

The samples that reached 32° F. (0° C.) in less than 5 minutes and had reached 25° F. (—4° C.) in less than 8 minutes were definitely the best in texture. Slight cottoniness was noted in those samples that had reached 32° F. (0° C.) in less than 10 minutes and 25° F. (—4° C.) in approximately 30 minutes. Those samples that required more than 30 minutes to reach temperatures below 25° F. (—4° C.) were rated cottony. Therefore, only those cooked potatoes which reached 25° F. (—4° C.) in less than a half hour were rated as "non-cottony" immediately after freezing.

In conclusion it may be said that the microscopic appearance of a sample of cooked, frozen, not reheated potato tissue gave an indication of its cottoniness. Those samples that were made up of "smooth" cells only were of excellent texture. When the cell contents were largely "net-like" or reticulated in appearance, the samples were still rated as "good." With the incidence of actual shrinkage, the texture was rated as increasingly "cottony." High freezing velocity was necessary in order to preserve smooth texture and avoid cottoniness altogether.

Next, the freezing velocities were varied by varying the distance between the freezer plate and equally sized samples.

Materials used and general procedure were similar to those used in the preceding experiment. The tubers used were of similar specific gravity and weight. They were mashed together, and six cylinders weighing 5 grams each were shaped. Two 5-gram samples were shaped into flat, one-square-inch pieces. In order to obtain more frequent recordings on the recording potentiometer and thus obtain more accurate curves, two pairs of thermocouples were inserted into representative samples.

Two flat and two cylindrical pieces were placed as closely as possible against the plate at which the temperature read —36° F. (—38° C.). The flat pieces made excellent contact, while the cylindrical ones touched at only one point. Two other cylindrical pieces were placed 1½ inches from the plate, where the air temperature read —31° F. (—35° C.). The last two cylindrical samples were arranged at a distance of 3 inches from the plate, at a temperature of —30° F. (—34.5° C.).

The results on freezing velocity, microscopy and palatability tests on these samples are summarized in Table 4. They resemble those presented in Table 3; with faster freezing rates, better texture was achieved. The "flat" samples which froze fastest, which did not show a flattening of the curve at 32° F. to 25° F. (0° C. to —4° C.) and which had reached a temperature of 25° F. (—4° C.) in 8 minutes were rated "perfect" in texture when tasted in the thawed, non-reheated state.

Results of Freezing Rates and Practical Applications. No gross changes were observed in the starchy cells of thawed cooked potatoes that had been frozen rapidly. The cells closely resembled those of freshly cooked potatoes and they were rated "perfect" in texture when tasted upon thawing, unreheated.

With increasingly slower freezing velocities, more cells showed reticulated contents. This reticulation may be looked upon as the beginning stage of retrogradation. The cells still felt smooth to the tongue.

As freezing velocities were further decreased, the cell contents began to shrink. Retrogradation of the gelatinized starch granules progressed and the sample assumed the characteristic feel of cottoniness. With increasing number of cells involved in the process of advanced retrogradation and shrinkage of contents, a sample felt increasingly cottony.

TABLE 3

Effect of Freezing Rate on Appearance of Cell Content and on Texture of Cooked, Frozen Potato Tissue

Different Freezing Velocities Were Obtained by Varying Sample Size

Weight of samples (grams)	Time from start to 32° F. (0° C.) (minutes)	Time from start to 25° F. (—4° C.) (minutes)	Appearance of cell content [a] 24 hours after freezing			Texture as judged by tasting 24 hours after freezing	Appearance of cell content after 2 months storage at —30° F. (—34.5° C.)			Texture as judged by tasting after 2 months storage at —30° F. (—34.5° C.)
			Smooth %	Reticulated %	Shrunken %		Smooth %	Reticulated %	Shrunken %	
2	Below 5	Below 8	100	0	0	Smooth	8	90	2	Smooth
4	Below 5	Below 15	86	14	0	Smooth	1	98	1	Smooth
8	Below 10	Below 30	56	0	44	Slightly cottony	0	8	92	Cottony
12	Below 15	Approx. 30	32	0	68	Cottony	0	0	100	Cottony
16	Below 15	Approx. 35	3	0	97	Cottony	0	0	100	Cottony

[a] 400 cells were counted.

TABLE 4

Effect of Freezing Rate on Appearance of Cell Content and on Texture of Thawed Cooked Potato Tissue

Different Freezing Rates Obtained by Varying Shape of Samples and Distance from Freezer Plate

Shape of sample	Distance from plate	Minutes from start to 32° F. (0° C.)	Minutes from start to 25° F. (−4° C.)	Minutes at critical zone 32° F. (0° C.) to 25° F. (−4° C.)	Appearance of cell content immediately after freezing			Texture as judged by testing (Palatability)
					Smooth %	Reticulated %	Shrunken %	
1. Flat, square	Flat side touching	Less than 5 min.	8 min.	3 min.	94.0	0	6.0	Smooth
2. Same	Same	.....	.....	.....	91.5	0	8.5	Smooth
3. Cylindrical	Barely touching	Approx. 5 min.	19 min.	14 min.	55.5	37.5	7.0	Smooth
4. Same	Same	.....	.....	.....	60.0	30.0	10.0	Smooth
5. Same	1.5 in.	Approx. 7 min.	28 min.	21 min.	9.0	26.0	65.0	Slightly cottony
6. Same	Same	.....	.....	.....	11.5	36.5	52.0	Slightly cottony
7. Same	3 in.	Approx. 12 min.	28 min.	16 min.	7.5	17.5	75.0	Slightly cottony
8. Same	Same	.....	.....	.....	5.5	13.0	81.5	Definitely cottony

Studies on the Effect of Storage on Cottoniness. For storage tests, twelve 5-gram samples were weighed out, shaped into flat, one-square-inch pieces and frozen against a plate at which the temperature registered —40° F. (—40° C.). Thermocouples were inserted into two of the samples and the freezing rates recorded on an electronic potentiometer. The temperature in the center of the samples dropped within 13 minutes to 0° F. (—18° C.) and reached —40° F. (—40° C.) within 28 minutes. Twenty-four hours later three samples were removed for microscopic examination and palatability tests. Three were transferred to —32° F. (—35.5° C.), 3 to —12° F. (—24.5° C.), and 3 to 0° F. (—18° C.) storage. All 9 samples were left in storage for 2 months, then removed, allowed to thaw only, examined microscopically and tasted for texture. Results are summarized in Table 5.

TABLE 5

Effect of Storage for Two Months at Different Temperatures on Microscopic Appearance and Texture of Rapidly Frozen, Cooked Potato Cells

(Average of 300 cells in each case)

Temperatures of storage	Microscopic appearance of cell content			Palatability of unheated samples
	Smooth %	Reticulated %	Shrunken %	Numerical Rating [b]
1. No storage	94.4	3.6	2.0	100
2. 0° F. (—18° C.)	66.0	26.3	7.7	98
3. —12° F. (—24.5° C.)	62.3	30.1	7.6	100
4. —32° F. (—35.5° C.)	47.0	32.0	21.0	85

[b] For explanation, see page 99.

During storage at the three temperatures used, a decrease in smooth cells and an increase in reticulated cells was observed. At —32° F. (—35.5° C.) storage resulted in a definite increase in the number of cells showing shrunken content. This increase was paralleled by a decline in palatability. The fact that storage at the lowest temperature resulted in an inferior product, seems puzzling. There is a possibility that the temperature of that particular freezer was not constantly as low as —32° F. (—35.5° C.). The freezer was located in a separate building and no continuous check on the temperature was made. Further work on the effect of storage on quality is desirable.

Freezing (and Storage) of Cells on Microslides. Pinhead-sized samples of mashed potato were smeared on 8 glass slides, then exposed to different temperatures without wrapping. Five slides were allowed to freeze at —30° F. (—34.5° C.) and three at 0° F. (—18° C.). The rate of freezing was not recorded. Previous tests in which thermocouples had been tied to the surface of slides and exposed to —40° F. (—40° C.) had not revealed significant differences between recordings made of thermocouples tied to glass slides and those recording air temperature. It was therefore assumed that the samples froze extremely fast.

After two hours one sample slide was removed from each freezer and examined microscopically. Two hundred cells were studied in each case. All were similar to freshly cooked, unfrozen cells. No trace of reticulation or shrinkage was observed. No observable differences between samples frozen at 0° F. (—18° C.) and those frozen at —30° F. (—34.5° C.) occurred.

Of the four slides left at —30° F. (—34.5° C.), two were stored at that temperature and two were transferred to 0° F. (—18° C.). Those frozen at 0° F. (—18° C.) were left at that temperature for storage.

After two months storage all slides were removed from the freezers. They were allowed to warm up at room temperature for 3 minutes. Then a drop of distilled water was placed on each slide, a cover glass applied, and the cells observed under the microscope. Two hundred cells were studied in each case. The results are shown in Table 6.

Although some dehydration of the cells must have taken place during two months of unprotected storage, over 90 percent of the cells "recovered" without reheating.

Since larger samples frozen at the same temperature and stored for the same period showed some reticulation of the starchy cell content, the present results seem to indicate that with increased freezing velocity, high quality (freedom from cottoniness) might be maintained to a still greater degree.

The question whether or not the cells smeared on slides actually "froze" deserves consideration. According to Tammann's research as reported by Luyet and Gehenio *(8)*, we must assume that when the temperature reaches a certain minimum, freezing becomes impossible because of the too intense cold. The object will not freeze but vitrify, and no crystallization takes place. According to Luyet and Gehenio, however, to achieve vitrification, the cooling velocity should be approximately a thousand times as high as that used in industrial "rapid freezing."

TABLE 6

Effect of Two Months' Storage at Different Temperatures on Microscopic Appearance of Cooked Potato Cells Which Had Been Spread on Microslides, Then Frozen

Freezing temperature	Storage temperature	Sample	Appearance of cells			
			Smooth %	Reticulated %	Shrunken %	Ruptured %
0° F. (—18° C.)	No storage	1	100.0	0.0	0.0	0.0
0° F. (—18° C.)	0° F. (—18° C.)	2	92.0	0.0	0.0	8.0
0° F. (—18° C.)	0° F. (—18° C.)	3	93.0	0.0	0.5	6.5
—30° F. (—34.5° C.)	No storage	4	100.0	0.0	0.0	0.0
—30° F. (—34.5° C.)	0° F. (—18° C.)	5	91.5	0.0	0.0	8.5
—30° F. (—34.5° C.)	0° F. (—18° C.)	6	91.5	0.0	2.0	6.5
—30° F. (—34.5° C.)	—30° F. (—34.5° C.)	7	90.5	0.0	1.0	8.5
—30° F. (—34.5° C.)	—30° F. (—34.5° C.)	8	93.0	0.0	0.0	7.0

Summary

1. Cottoniness, as used in this study, refers to a texture of cooked, frozen potatoes which feels dry and wet, or moist, at the same time.

2. The crystallographic method described by Friess *(4)* was not suitable for the detection of cottoniness in cooked, frozen potatoes.

3. Microscopy proved to be a great aid in the detection of cottoniness. Cells representing cottony tissue were somewhat smaller than freshly cooked cells, showed considerable shrinkage of their contents and were also more or less angular in shape.

4. While freshly cooked, unfrozen, starch-containing potato cells were packed with swollen starch granules whose delicate outlines allowed the cell contents to appear more or less smooth, the cells of frozen tissue were observed to change more or less, according to the conditions under which the samples had been frozen. In some cases, the only observed change was a tendency for the cells to rupture readily, especially upon boiling. In others, fine to coarse strands had appeared in the cells, giving the cell content a reticulated appearance. In others, the cell content showed shrinkage and the cell walls gave in, thus assuming somewhat angular outlines.

5. Samples containing a preponderance of ruptured cells felt slimy. Cells resembling those of unfrozen tissue as well as those showing reticulation felt smooth to the tongue. With an increasing number of cells with shrunken content, the samples were rated as being more and more cottony.

6. Cottony samples had to be reheated to a definite temperature in order to become restored through absorption of moisture.

7. Reswelling of cells was observed to begin at 123° F. (50.5° C.) and to be completed at 133° F. (56° C.) but with insufficient moisture available during the process of reheating, a complete reswelling did not occur and traces of cottoniness remained.

8. Cottoniness was avoided altogether by employing very rapid rates of freezing. Samples which reached a temperature of 32° F. (0° C.) in less than 5 minutes and had reached a temperature of 25° F. (—4° C.) in less than 8 minutes showed a "smooth" appearance of their cell contents, no reticulation and no shrinkage. Palatability tests rated those samples as "smooth." Samples which took about 7 to 10 minutes to reach 32° F. (0° C.) and approximately 30 minutes to reach 25° F. (—4° C.) were judged slightly cottony. Storage (for 2 months) of rapidly frozen, smooth-textured samples at 3 different temperatures (Table 5) resulted in a slight increase in the number of reticulated and shrunken cell contents. Samples stored at —12° F. (—24.5° C.) and 0° F. (—18° C.) seemed little changed and their texture was given high ratings in palatability tests.

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Conducting a Taste Panel for the Evaluation of Edible Oils[a]

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The development of taste panel methods used to evaluate edible oils is described. The importance of a well organized procedure, the maintenance of interest, and the evaluation of panel and individual performance by statistical means is discussed.

When soybean oil was first produced domestically in marketable quantities in 1922, the greater portion of it was used for non-edible purposes such as the manufacture of paint, linoleum, and soap. By 1943, however, there was a decrease in the "drying oil" usage and a large increase in the edible uses. Ninety percent of the soybean oil in that year went for edible purposes *(1)*. Utilization of soybean oil for food use has increased almost three-fold in the past 10 years so that by 1948 the annual consumption by the food industry was on the basis of 1,100 million pounds, of which 750 million pounds went into shortening, 200 million pounds into margarine, and 150 million pounds into salad oils and other food products.

Part of this spectacular rise in the use of soybean oil for edible purposes resulted from the wartime shortage of edible fats. While soybean oil has many good features, its use in food products presents one definite problem —its lack of flavor stability. The solution of this problem is of paramount importance to the oil processors and the manufacturers of edible fats who sell their products to a public accustomed to bland and flavor-stable oils.

Work on the flavor stability of soybean oil was started at the Northern Regional Research Laboratory in 1944. Because existing physical and chemical tests were unsuitable for measuring this off-flavor development, organoleptic methods for evaluation were investigated. Many edible products were being evaluated by means of taste panels. Tea, coffee, wine, and kola beverages were being evaluated by tasters; dairies were using butter and milk tasters. Metzner reported various procedures followed in the taste testing of beer *(2)*. So it seemed that organoleptic tests should be extremely useful for evaluating soybean oil which was to be used for salad oils, other food products, and for deep-fat frying. Because of the nature of the research to be done it was necessary to set up an analytical rather than the consumer type of taste panel. Since the samples of oil to be evaluated would be given various treatments, it was important to have that type of panel which could detect small differences between treated and untreated oils. Hence, the selection and training of the individuals comprising the panel and their sensitivities and consistencies were of extreme importance.

In an earlier paper the method used to establish the first taste panel was described. Briefly, a group of people were given preliminary acuity tests patterned after the procedure of the Bureau of Human Nutrition and Home Economics, U. S. Department of Agriculture *(3)*. After eliminating those who had very high thresholds or made incorrect identifications, the remainder of the group was given a second series of tests to further check their performance. A panel was selected from this group and were trained to evaluate oil samples.

Oil tasting presented problems different from those of coffee, tea, or other food tasting. One of the first items to be considered was that of temperature. An individual can detect the odors and flavors of warm oil much more readily than of cold oil. Also, the mouth "feel" is much more pleasant when the oil is warm and does not detract from the concentration on odor and flavor. To present warm samples to the taste panel members was difficult. In order to have all members taste the samples at the same temperature, and to be able to repeat this temperature, a hot plate was designed which would hold all the samples at the required temperature of 55° C. for the half hour of taste panel operations. The unit consisted of an electrically heated aluminum plate on which were placed the small aluminum blocks designed for holding 50-ml. beakers in which the oil samples were presented to each individual taste panel member. Thus the physical condition of the samples presented was standardized and this uniformity contributed to the consistency of results.

Another problem was that of taste fatigue. At the very beginning of the taste panel as many as six samples were presented at one time. Panel members in general agreed that this number was too great for accurate results. Because the oil tends to cling to the inside of the mouth there was often a carry-over of flavors from one sample to the next. By the time the sixth sample was tasted the accuracy of the score was questionable, even though the mouth was rinsed with warm water between samples. Where fewer samples were presented a more thorough rinsing of the mouth could be given and the entire process made less time-consuming. Eventually, the paired-sample technique was found to give more accurate and more consistent results and except in the case of the samples as they come from the 4-sample deodorizer, we now present only two samples at each tasting. These paired samples are presented following the method outlined by Ross for the presentation of stimuli in such a way as to obtain balance and maximal spacing and yet avoid suggestive repetitions *(6)*. Bengtsson and Helm of the Stockholm and the Carlsbad Breweries, respectively, also found that a small number of samples was desirable in the tasting of beer *(4)*. On the other hand, Burrows felt that with fats of good quality, he could evaluate satisfactorily 10 samples *(5)*.

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[b] One of the Laboratories of the Bureau of Agricultural and Industrial Chemistry, Agricultural Research Administration, U. S. Department of Agriculture.

At the close of each day's tasting, the scores assigned to the samples by the panel members were averaged and the t-test applied to the means of the scores of the samples. Student's t-test was used because it can be applied to a small number of samples. This showed whether the difference in the means was due to chance or whether the difference was real, the result of the treatment given the oil. The use of this procedure for the statistical analysis of each day's scores has been continued.

More recently the physical conditions under which our taste panel is operated have been improved although the methods of procedure have remained essentially the same. Fig. 1 shows the floor plan for the taste panel

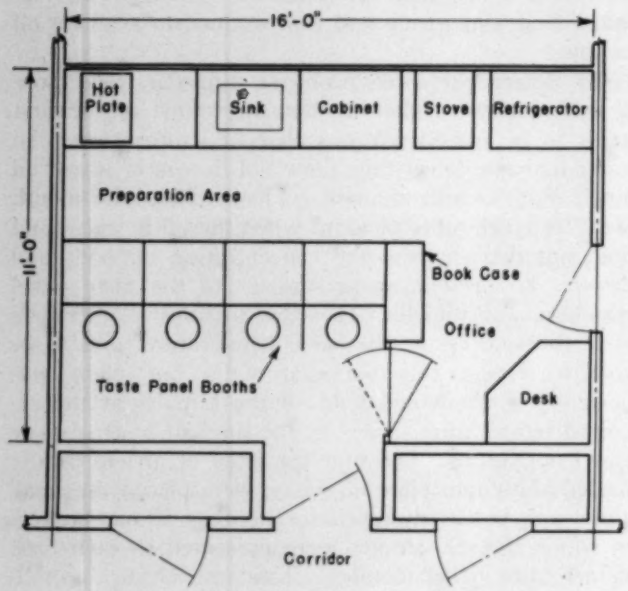

Fig. 1. Floor plan of taste panel room.

room where all preparations and evaluations are made. This room is held at a constant temperature of 25° C. and a relative humidity of 40 percent. The method of presenting samples through the sliding doors to the taste panel member is shown in Fig. 2.

Fig. 2. The preparation area of the taste panel room at the Northern Regional Research Laboratory. The attendant is passing samples of oil in a heated aluminum block to the taste panel member on the opposite side of the partition.

After tasting the samples and recording his evaluations on the standard score sheet shown in Fig. 3, the panel member compares his evaluation with those of other panel members.

NAME John Doe DATE 6-24-49

PLEASE INDICATE THE SCORE BY PLACING A CHECK MARK (✓) IN THE SPACE OPPOSITE THE PROPER INTENSITY.

		SAMPLE 1		SAMPLE 2		SAMPLE 3		SAMPLE 4	
		O	F	O	F	O	F	O	F
	10								
GOOD	9	✓	✓						
LESS DESIRABLE	8			✓					
BUT ACCEPTABLE	7				✓				
	6								
OBJECTIONABLE	5								
	4								
UNPLEASANT	3								
	2								
REPULSIVE	1								

PLEASE INDICATE INTENSITIES OF FLAVORS BY PLACING CHECK MARKS OPPOSITE THE PROPER FLAVOR.
(✓) WEAK; (✓✓) MODERATE; (✓✓✓) STRONG.

	SAMPLE 1	SAMPLE 2	SAMPLE 3	SAMPLE 4
BLAND				
BUTTERY	✓			
BEANY		✓✓		
RANCID				
PAINTY				
Tallowy		✓		

Fig. 3. Score sheet used by taste panel members in evaluating oils.

The opportunity to discuss the samples at this time lends much to maintaining interest in the work. Meetings of the entire taste panel are held often to give the members the results of completed work. These discussions tend to create interest in the work and such interest is extremely important in holding a panel together. Bengtsson states in a recent paper that "interest is the prime attribute of a good taster" *(7)*.

Because occasionally some of the experienced taste panel members leave the laboratory and because of absences due to vacations, it has become necessary to have trained substitutes available so that a uniform number of tasters can be maintained and thus assure more reliable results. Feeling that perhaps the threshold tests for the primary tastes were not important in oil tasting, it was planned to train a new group of individuals by using oil samples. The training of this new group was purely experimental as there were no prescribed procedures for oil tasting set up by industry or research organizations. A three weeks' training period was used to familiarize the training panel with procedures and with the flavors of the oils with which they would be working. While it was felt that a longer training period would be desirable, a good agreement in results was shown.

In order to utilize the services of the new group to the best advantage, it was necessary to measure individual as well as panel performance. By giving the same tests to both the training and the experienced panels, it would then be possible to evaluate the results statistically and on this basis, select a taste panel whose precision should improve.

Two methods of analysis were used to measure panel performance and individual performance. The first, the control chart method which measures the reproducibility of the individual's scoring on a single oil, is shown in Fig. 4. The same oil was presented 20 times and the results supplied the data from which the control charts were drawn. The discontinuous lines for the limits in these figures result from the allowance made

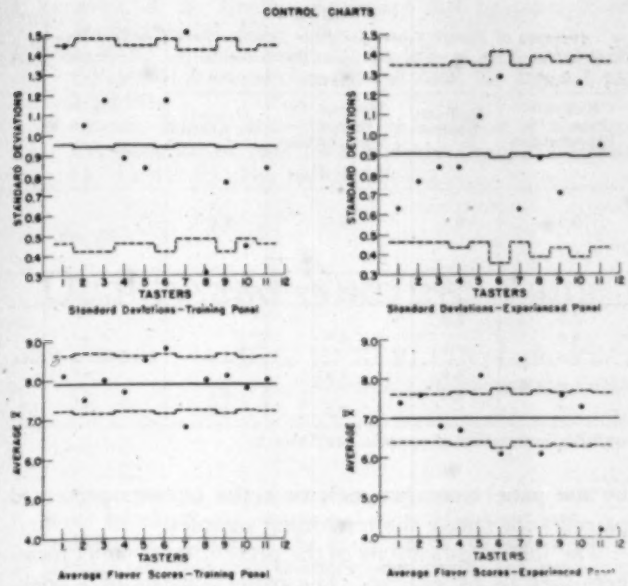

FIG. 4. Control charts showing average flavor scores and standard deviations for tasters from both training and experienced panels.

for the unequal number of tastings by panel members. From the chart showing averages for the training panel we see only two members were outside the limits, while five of the experienced panel members were outside the limits. This indicates that some of the experienced taste panel members were grading the oil samples high and some were grading them equally low. The control chart on standard deviations shows that each member was consistent in his grading of the samples whether he graded high or low, but that the panel as a whole was not consistent in its thinking as to the quality of that oil sample. It is interesting to note that taster No. 7 on the control chart of standard deviations for the training panel was outside the upper limit and his scoring was erratic. That same taster was outside the limits on the control chart of averages. The fact that only one member was outside the upper limit on the control chart of standard deviations for the training panel may indicate that the group as a whole benefited by its discussions concerning the evaluation of samples during the training period and, therefore, the members were reacting more along the same lines. Tasters No. 8 and 10 on this same chart have small standard deviations and may be considered very reliable tasters.

The second method for determining individual and panel performance was the correlation and regression method, used to measure the ability of the individual to distinguish differences between oils. Twenty-two paired samples of oil were presented at various times throughout the test period. The samples were made up of control samples and pairs of oils which had been stored 1, 3, 7, and 15 days at 60° C. The individual's score was correlated with the average score of the remainder of the panel. The correlation coefficients for the training panel ranged from 0.55 to 0.88 while those of the experienced panel ranged from 0.56 to 0.90. The regression coefficient, which shows how many units the individual score changes for each unit change in the panel average, ranged from 0.62 to 1.84 for the training panel and 0.40 to 1.33 for the experienced panel. Scatter diagrams are shown in Fig. 5 for the tasters from both the training panel and the experienced panel who had the highest and lowest correlation coefficients. Such diagrams show at a glance the relationship between the two variables, the individual score and the panel average; they also show the amount of change in individual score for each unit change in the panel average; and how nearly the estimated values agreed with the values

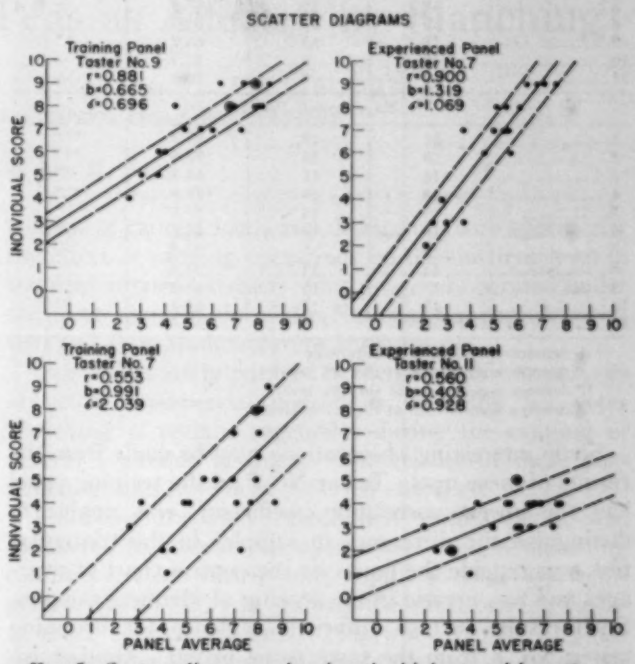

FIG. 5. Scatter diagrams showing the highest and lowest correlation coefficients of tasters from both training and experienced panels.

actually observed for the variable being estimated, and the accuracy with which predictions can be made under the same conditions.

To determine the individual's ability to differentiate between two samples, the "triangular test" was used. In this test three samples were presented to the taster. Two were identical while the third was different. Each time this test was presented the panel members were asked to select the two samples which were identical. The degree of difference in these two samples is of great importance. If the difference in the oils is too great, it would be detected by even the poorest tasters. If the difference is too slight, chance selection alone could give correct answers once out of every three trials. When the number of tests is small, one cannot assume that chance will produce exactly 33 percent of correct answers. It is necessary in such cases to know how far the number of correct answers must exceed 33 percent before one may be certain that guessing is eliminated. This can be calculated according to Bengtsson's adaptation of the chi-square analysis to the triangular test *(8, 9)*. Table 1 shows the results of the triangular test presented to the training and experienced panels. Experience seems to have some influence on this test as the results of all but two of the experienced tasters are significant while the results of all but five training panel members are significant.

TABLE 1

Results of Triangular Tests

Taster	No. Times Tasted	No. Correct[a] Responses	% Correct Responses	Significance of Results[c]
Training Panel				
1	18	11	61.1	*
2	17	10	58.8	*
3	18	11	61.1	*
4	15	7	46.7	+
5	15	5	33.3	+
6	16	10	62.5	*
7	19	9	47.4	+
8	20	13	65.0	**
9	18	12	66.7	**
10	18	6	33.3	+
11	18	9	50.0	+
Experienced Panel				
1	20	19	95.0	***
2	18	14	77.8	***
3	16	11	68.8	**
4	18	14	77.8	***
5	19	11	57.9	*
6	14	9	64.3	*
7	19	7	36.8	+
8	15	14	93.3	***
9	17	15	88.2	***
10	18	12	66.7	**
11	18	9	50.0	+

[c] + denotes no significant difference
* denotes significance at the 5% level
** denotes significance at the 1% level
*** denotes significance at the 0.1% level

Some interesting observations may be made from the results of these tests. Taster No. 7 on the training panel had the lowest correlation coefficient, was unable to distinguish the difference in samples in the triangular test, was outside the limits on the control chart of averages and was erratic in the scoring of identical samples. Such results furnish sufficient evidence for dropping taster No. 7 from the taste panel group. Another interesting case is that of Taster No. 7 on the experienced panel. Although he had the highest correlation coefficient 0.90, he had one of the lowest percentages of correct answers in the triangular test. This is difficult to explain since this particular individual has a very keen sense of smell. It was evident throughout, however, that there was a psychological reaction each time this test was given and perhaps the factor of confusion caused such a response. Another explanation is that this same taster was unable to detect diacetyl in low concentrations and perhaps he could not detect the buttery flavor in this oil. The control charts showed that while this same individual graded slightly higher than the panel, as a whole he was consistent in his grading.

After a careful study of the results of these tests, a panel of 18 persons was chosen from the entire group of 22. After a 4-month period of regular tasting the results of this group were evaluated by the correlation-regression method. With the exception of two persons, the panel showed good agreement. In the cases of those two persons, known causes accounted for their slightly below average performance.

Table 2 shows some typical results of one run. The samples as they came from the deodorizer were about the same in quality and were rated good. Ten is the highest possible score and is reserved for bland oils. After these oils were stored at 60° C. for 4 days they were again evaluated by the paired-sample technique. Off-flavors had developed as can be seen from the scores assigned the oils. The consistency of the panel is shown

TABLE 2

Averages of Flavor Scores for Four Samples Tested in One Run[d]

1 Raffinate Plus .02% Phosphatides	2 Raffinate Control	3 Original Oil Plus .02% Phosphatides	4 Original Oil Control	Sig. Dif.
0 Time				
8.7	8.4	8.7	8.6	No diff.
After 4 Days' Storage at 60° C.				
6.9	5.8			*
6.6		6.9		+
6.6			6.6	No Diff. in Means
	5.9	7.4		**
	6.2		6.5	+
		7.5	6.8	+

[d] For explanation of symbols, see Table 1.

by the panel averages each time the oil was presented paired with one of the remaining samples.

The job classifications of the present taste panel members may be of interest. The panel consists of a bookkeeper, a technical editor, 7 chemists, a technical analyst, 3 chemical engineers, 2 agronomists, and 2 administrators. Type of work apparently has no influence on the taster's ability to judge oils, for the statistical analysis shows that a chemical engineer and an administrator had the highest correlation coefficients. That smoking has not affected the results of the panel is indicated by the fact that one of these two tasters is a chain smoker and the other is a non-smoker.

From the work done at this Laboratory, a few general observations might be made. First, that through a well-planned training program, most individuals can be trained to become oil tasters. Second, that interest in the work is very important. Third, that regularity, quiet and comfortable surroundings, orderliness, and smoothness of presentation contribute to more accurate and consistent evaluations. Fourth, that statistical evaluations such as those described enable the director of a taste panel to watch for assignable causes of variation in individual as well as in panel performance. Finally, since there is no known chemical or physical test to detect off-flavor development in soybean oil, it seems clear that the organoleptic method must be used and that any refinement or improvement in methodology is important to this line of research.

Acknowledgment

Grateful acknowledgment is made to the taste panel members for their conscientious cooperation, and to the various members of the Laboratory for their continued assistance.

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Quality and Nutritive Value of Peas as Affected by Blanching[a]

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Experimental water blanching of sweet peas has been compared with commercial water blanching, evaluating the relation of the operation to the nutritive factors, ascorbic acid, thiamine, and niacin, and quality factors including flavor and tenderness of the canned product. High-temperature, short-time blanches were found to be beneficial to increased ascorbic acid retention, but did not significantly increase the retentions of the other factors studied. Quality tests indicated no commercially detectable differences.

An investigation of pea blanching operations has been conducted to determine, through the use of laboratory-size equipment, how present commercial blanching equipment might be operated to improve the nutritive value of the canned product and maintain at least equal quality. This report describes such experiments with a laboratory model of a rotary-type water blancher operating in parallel with a commercial rotary-type water blancher.

Blanching is one of the operations considered to be necessary in the successful canning of peas. In the sequence of the several operations involved in canning, blanching is carried out after the peas have been cleaned, and in most instances separated into sieve sizes, and usually precedes salt brine quality grading. Fundamentally, blanching involves immersion of the product in hot water or an atmosphere of steam for a controlled period of time. The rotary blancher, almost universally used for peas, is basically a large horizontal cylinder containing a screw conveyor which is approximately half-immersed in a hot water bath. Peas enter one end and are carried along by the pitch of the interior spiral as they float or are immersed in the hot water, finally emerging at the opposite end. Varying speeds of the spiral govern the length of time for the blanching operation.

Early studies on the effect of commercial canning on the vitamin or nutrient content of canned foods have been summarized previously *(5, 15, 16)*. In 1942 plans were drawn by various members of the industry for establishment of a program to investigate the nutritive content of canned foods and determine more specifically the effect of canning operations on the nutrient level in the final canned product. This program operated under the joint sponsorship of the National Canners Association and Can Manufacturers Institute *(4)*.

One line of study pursued in the program was surveys of actual commercial operations including hot-water blanching of certain vegetables during the canning of several vegetable products. The results of these particular studies have been reported elsewhere *(8, 13, 15)*.

Following the above mentioned studies, work was conducted in commercial operations wherein blanching conditions were varied with regard to time and temperature in an effort to evaluate the effect of such variations on certain nutrients. This work *(9, 10, 16)* has indicated that by shortening the time and elevating the temperature of the blanching operation, the retention of several nutrients will be increased significantly.

Reviewing the results of these surveys of commercial hot water blanching leads to the conclusion that it should be possible to improve the retention of water-soluble nutrients in certain vegetables during commercial canning by variations in the blanching schedules commonly employed. To investigate this conclusion in greater detail, two courses of action were recommended. One plan involved the use of a commercial blancher being operated for a period of time at some suggested high-temperature, short-time blanch. The results of such tests have been reported in detail elsewhere *(7, 12)*. The second plan of action is described in this report.

Experimental Procedure

The various tests which were a part of this study were conducted in a Northern Illinois vegetable cannery using peas of the Prince of Wales variety. Blanching was conducted in a commercial rotary-type blancher or in a small experimental rotary blancher. The experimental blancher was installed in parallel with one of the commercial blanchers being operated continuously during the pack. By such an arrangement, it was possible to divert peas destined for the commercial blancher into the small experimental equipment and thus have commercially blanched peas of the same lot available for control purposes. Blanching conditions in the small experimental blancher could be varied over a wide scale,

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thereby providing greater variation than could be obtained with commercial equipment.

The previously mentioned experimental blancher was not new in design, but was similar to the large rotary blanchers commonly used, and built to scale size. The tank dimensions were: length—40 inches (101.6 cm.); width—13 inches (33.0 cm.); and depth—8.5 inches (21.6 cm.). The blancher reel was approximately 38 inches (96.5 cm.) long with a 12-inch (30.5 cm.) diameter and containing a spiral to convey the peas from end to end. All metal parts consisted of tin plate or galvanized plate and screen. The reel turned on a set of rollers within the tank and the source of power was an electric motor of variable speed driving a set of gears activating the blancher reel.

With the small blancher placed at the side of the commercial blancher, a pumping system was devised to remove blanch water from the commercial blancher and circulate it to the experimental tank. Heating of the blanch water was accomplished by a steam coil in the bottom of the tank. This arrangement permitted experimental blanching of the same lot of peas being commercially blanched and using the same blanch water as the commercial blancher, thus making it possible to control two more variables which might have an effect on vitamin assay results.

The canning line used in this study was representative of other pea canneries where quality grading is conducted on blanched peas, rather than raw peas. Such a procedure is to be preferred, and is being employed to a greater extent with each passing season. The vined peas were first cleaned in a clipper cleaner and then washed with water. The washed peas (field run) were transported by hydraulic lift to the hopper of the rotary blancher, and then blanched at 205° F. (96.0° C.) for either five or six minutes, depending on the field grade or tenderometer reading of the raw peas. The blanched peas were washed in the water used to transport them by hydraulic lift from the blancher outlet to the quality separators. After salt brine separation into fancy (floaters) and standard (sinkers) grades, the peas were held briefly in cold water tanks (for periods varying from zero to 15 minutes), after which they moved by gravity in water sluices to dewatering screens, then to inspection belts, the filler hopper, and into No. 303 or No. 2 cans. Brine was added and the filled cans were closed under vacuum. The cans of peas were processed 35 minutes at 248° F. (120.0° C.) in four-crate, vertical retorts, followed by water cooling in the retorts.

The quantity of product passing through the experimental blancher was too small for quality grading by the usual commercial methods, so all samples were canned ungraded. Likewise, to serve as controls, sufficient commercially blanched peas were taken from the line before quality grading, and were handled in the same manner as the experimental lots after blanching. Both experimental and commercial control samples were washed with water after blanching and prior to canning to simulate cannery operations.

Examination of Samples

The vitamins ascorbic acid, thiamine, and niacin were determined on all samples. In each experiment listed in the schedule of blanching in Table 1, samples for analysis were taken just before the blancher, immediately after blanching and after processing. In a few instances, samples of blanch water were taken during the experiment. The method of handling the samples in the field for thiamine assay has been described earlier *(5)*, with the final B-complex slurries being prepared in the laboratory *(15)*. Niacin assays were conducted on the same slurry samples used for thiamine. Ascorbic acid was determined on the raw and blanched samples and blanch water samples at the site of the work. The processed samples were analyzed as soon after canning as was feasible to eliminate any storage effect. Slurries for ascorbic acid assays were prepared according to Wagner et al. *(15)*, substituting 6% metaphosphoric acid as a stabilizing medium for all raw and blanched samples, while 3% acid was used for all processed samples. Moisture samples were taken for each assay.

TABLE 1

Blanching Schedule for Sweet Peas

Tenderometer Grade	Blanching Temp. ° F.	Blanching Time (min.)			
Under 105 [b]	185°	1	4	8	
Under 105 [b]	202°	1	3	6	
116-145 [c]	185°	1	5	8	
116-145 [c]	202°	1	3	5	7

[b] Hereafter called "Immature peas."
[c] Hereafter called "Nearly mature peas."

Ascorbic acid was titrated in the final filtrates with a standard solution of 2, 6-dichlorophenolindophenol dye, buffered with sodium bicarbonate to pH 8.0 to 8.5 and taking the end point as a faint pink color persisting for 10 seconds *(2)*.

Thiamine was assayed by the thiochrome method *(6)*. Niacin was determined by the microbiological method *(14)* with some modifications *(11)*. Total solids determinations were made according to the A. O. A. C. vacuum-oven technique on canned samples *(1)* prepared for this purpose consisting of weighed amounts of peas and water.

Quality evaluations of the color of the canned product (both solids and brine), flavor, and tenderness were made by a panel of expert graders from the industry. These quality tests also were applied to the samples involved in the reports of Lamb et al. *(12)* and Feaster et al. *(7)* and the results have been incorporated in this publication.

The vitamin data were calculated on the dry solids basis and in the canned samples corrections were made for added salt and sugar. Although other methods of calculating results of such surveys have been proposed, this method (dry solids basis) yields representative results for comparative purposes. It is the same as that used by several other workers *(8, 9, 10, 15, 16)*.

Results and Discussion

The vitamin values for the many samples are not included herein but instead the percent retentions have been summarized in Tables 2 and 3. The significance of the differences between experimental and control lots may be obtained by inspection of the Figures 1 to 4. The vitamin retentions of both blanched and processed samples are shown so that the effect of the blanching

operation reflected in the retentions of the processed samples may be observed.

Ascorbic Acid. In tests with immature (low tenderometer grade) sweet peas, experimental blanching temperatures of 185° and 205° F. (85.0° and 96.0° C.) were employed. Table 2 lists ascorbic acid and thiamine retentions, calculated on the dry basis, for the two experimental temperatures at various lengths of blanching time and the retention simultaneously obtained on a commercial control blanch of five minutes at 205° F. (96.0° C.). It should be emphasized that each control sample is from the same lot being treated experimentally. Considering the lower blanching temperature first, it will be seen that the best ascorbic acid retention after blanching was obtained with a four minute blanch. After processing this condition was reversed in one instance and the poorest final retention of ascorbic acid was obtained with this previously best blanch.

The best over-all retention for the experimental 205° F. (96.0° C.) blanch was observed in the one minute treatment and this benefit was reflected in the processed samples. This condition was the reverse of that observed in the 185° F. (85.0° C.) blanch after processing and may be explained by differences in degree of enzyme inactivation and air removal.

In Figure 1, the ascorbic acid data from Table 2 have been graphed after subtracting retentions of control lots from retentions of comparable experimental lots to obtain a measure of the degree of improvement. In instances when the experimental retentions were higher than the control lots the difference has a positive value, but if it was lower than the control lot the difference has a negative value. In this first graph the data from blanched peas show that as the blanching time increased the difference between experimental and control lots decreased. Comparison of the two experimental temperatures indicates the same general trend although the 205° F. (96.0° C.) blanch seems to have the most favorable retention differences. Comparing the processed samples shows significantly the benefit of the 205° F. (96.0° C.) blanch. The explanation for this, again, is the greater degree of enzyme inactivation and more complete air removal accomplished by the higher blanching temperature.

TABLE 2

Retention of Ascorbic Acid and Thiamine During Blanching Immature Sweet Variety Peas

Experimental Condition	Percent Ascorbic Acid Retained[d]			Percent Thiamine Retained[d]		
	185° F.	205° F.	Control[e]	185° F.	205° F.	Control[e]
Raw	100	100	100	100	100	100
Blanched 1 min.	90	100	73	99	100	88
Processed, 35 min. @ 248° F.	66	77	63	53	53	49
Blanched 3 min.	....	83	75	....	95	90
Processed	....	59	50	....	61	67
Blanched 4 min.	98	....	98	99	....	99
Processed	53	....	79	61	....	60
Blanched 6 min.	....	75	73	....	100	95
Processed	....	57	55	....	73	65
Blanched 8 min.	80	....	74	88	....	89
Processed	62	....	64	61	....	68

[d] Retentions calculated on dry solids basis.
[e] Commercial water blanch, 5 min. @ 205° F. (96.0° C.).

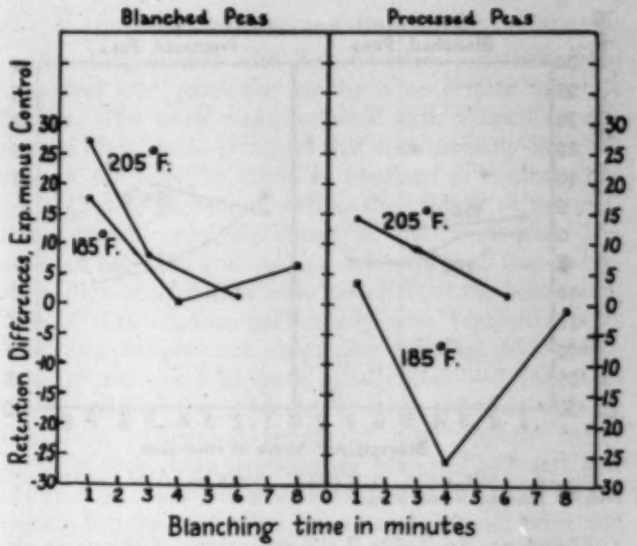

FIG. 1. Differences in Percent Ascorbic Acid Retention—Immature Sweet Peas.

The ascorbic acid retentions obtained with nearly mature[f] (high tenderometer grade) peas are shown in Table 3. It will be noted that the retention after blanching for all practical purposes was the same for experimental and control lots. Retentions of that vitamin in processed samples from each lot also were similar although somewhat less than the blanched samples. In Figure 2 the differences between experimental and control retentions are shown graphically and any differences between the 185° F. (85.0° C.) and 202° F. (94.5° C.) blanches are shown to be small. It will be noted that this condition is somewhat different than that observed in the case of the immature peas, where the 205° F. (96.0° C.) blanch was generally better than the 185° F. (85.0° C.) blanch.

TABLE 3

Retention of Ascorbic Acid and Thiamine During Blanching Nearly Mature Sweet Variety Peas

Experimental Condition	Percent Ascorbic Acid Retained[g]			Percent Thiamine Retained[g]		
	185° F.	202° F.	Control[h]	185° F.	202° F.	Control[h]
Raw	100	100	100	100	100	100
Blanched 1 min.	88	85	85	97	95	87
Processed, 35 min. @ 248° F.	72	75	68	52	53	49
Blanched 3 min.	....	90	90	....	88	94
Processed	....	78	79	....	53	57
Blanched 5 min.	....	86	91	....	88	94
Processed	....	68	74	....	45	60
Blanched 5 min.	82	....	81	95	....	96
Processed	75	....	66	58	....	53
Blanched 7 min.	....	77	81	....	86	98
Processed	....	65	73	....	48	62

[g] Retentions calculated on dry solids.
[h] Commercial water blanch, 5 min. @ 202° F. (94.5° C.)

[f] For purposes of identification in this paper nearly mature peas are those of 116 tenderometer grade or higher, and immature peas are those of 105 tenderometer grade and lower.

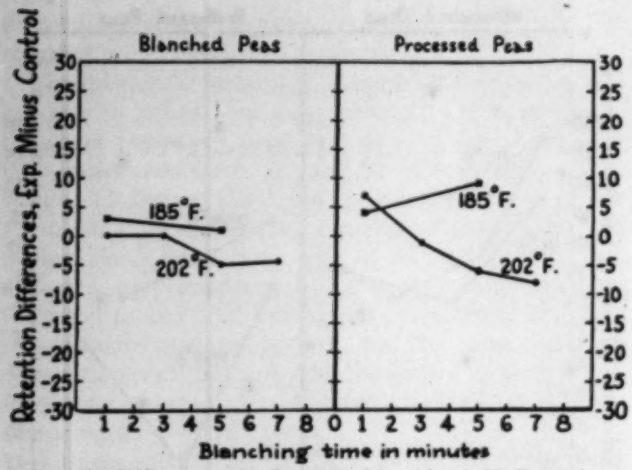

FIG. 2. Differences in Percent Ascorbic Acid Retention—Nearly Mature Sweet Peas.

Thiamine. In Table 2 the retentions of thiamine obtained during the blanching of immature sweet peas also are shown. Experimental temperatures of 185° and 205° F. (85.0 and 96.0° C.) are shown as well as the commercial control samples which were blanched five minutes at 205° F. (96.0° C.). It will be noted that the loss after blanching in most instances was less than 10% of the original thiamine present in the raw peas. This observation is true also in the control lots. The greatest change in thiamine content was associated with the longer blanching periods.

In Figure 3 the differences in percent thiamine retention between the commercial and experimental samples are shown graphically. Considering the blanched peas, it will be seen that the differences between the 185° and 205° F. (85.0° and 96.0° C.) test samples were not significant. As the blanching time increased the difference between experimental and control lots became more nearly the same, with practically no difference at times greater than four minutes. With the processed peas of the same lots under discussion, it was found that the difference between experimental and control samples was not significant except in the case of the 185° F. (85.0° C.) blanch for eight minutes. This difference might be expected since the length of the blanch was somewhat longer than the control sample.

Thiamine retentions for the nearly mature sweet peas are shown in Table 3 which includes the experimental and commercial lots while the differences between percent retentions of such lots are graphed in Figure 4. As previously noted the blanching temperature for the commercial control sample was five minutes at 202° F. (94.5° C.). The results observed with this grade of peas are not as easily explained. Considering the data in the graphs it will be noted that with the blanched peas the difference between experimental and control lots varied as the blanching time increased until the difference became negative or decidedly in favor of the control lots. The only explanation which can be offered for this discrepancy is that the commercial blancher was more heavily loaded than was the experimental blancher with the resultant effect that the water soluble constituents may have been leached from the experimental lot to a greater degree than occurred with the commercial control lot. The differences between experimental samples were reflected in the processed lots of the same samples.

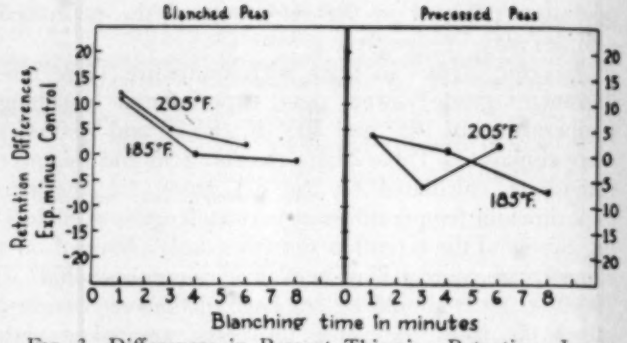

FIG. 3. Differences in Percent Thiamine Retention—Immature Sweet Peas.

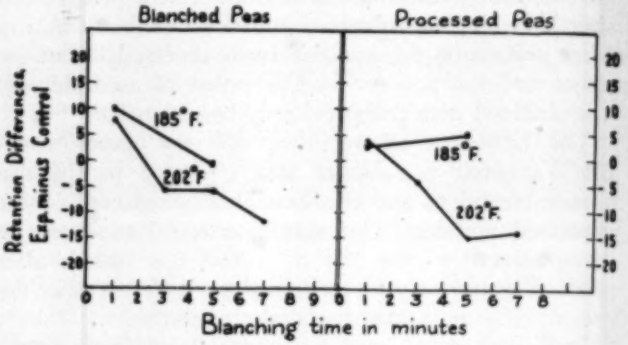

FIG. 4. Differences in Percent Thiamine Retention—Nearly Mature Sweet Peas.

Miscellaneous Observations on Vitamin Retention

Recently Cameron et al. *(3)* have surveyed the considerable volume of literature which has been developed on nutrient retention during commercial canning and have summarized the data obtained in major studies in this field. Vitamin data for both blanched and processed peas were included in their summarization. This information has been tabulated together with the experimental information from the present study. The range of retentions together with the averages for both the published and experimental studies may be found in Table 4. It is of interest to note that in most instances the range of experimental retentions coincides with the commercial or published values. In some instances the average figure for the experimental data is slightly higher than the published commercial figures but this may be attributed to the very short blanching times employed in the experimental studies included in the range and averages. The fact that the published and

TABLE 4

Comparison of Vitamin Data for Blanched and Processed Peas
(Commercial[1] and Present Experimental Data)

Vitamin	Commercial[1] or Experimental	% Retention After Blanching		% Retention After Processing	
		Range	Average[2]	Range	Average[2]
Ascorbic Acid	Com.	60 to 90	76 (60)	45 to 90	72 (43)
Ascorbic Acid	Exp.	61 to 100	82 (22)	49 to 81	68 (22)
Thiamine	Com.	73 to 100	88 (60)	40 to 70	54 (54)
Thiamine	Exp.	86 to 100	94 (22)	45 to 73	54 (22)
Niacin	Com.	59 to 96	73 (39)	50 to 80	65 (32)
Niacin	Exp.	55 to 98	75 (22)	48 to 95	69 (22)

[1] Taken from Cameron et al. *(3)*.
[2] Parenthetical number is the total of samples included in the average.

experimental figures coincide so closely leads one to deduce that the published figures include both long and short blanches. It should be noted that this table includes information on niacin assays which were also conducted in this present study but have not been included in the previous discussion due to the lack of new information.

The fact that thiamine does not undergo any oxidative change during the blanching operation enables one to observe quite accurately the leaching effect. It has been noted previously *(5)* that when peas are separated into various sieve sizes before blanching, the thiamine content of the small sizes is significantly affected during blanching. Apparently the maturity of the vegetable has a noticeable effect on leaching of the water soluble constituents, being more pronounced with the immature peas and decreasing with increasing maturity. Further evidence of this may be shown with the immature and the nearly mature field-run peas employed in this study. The data in Tables 2 and 3 substantiate this observation.

Quality Observations

The results of the several quality examinations conducted on the samples from the previously described tests are not tabulated in this report. This procedure was adopted because the differences between experimental and commercial control lots were not found to be significant in any of the lots examined. In most instances duplicate samplings were examined and the results grouped together. In the actual testing or examination these duplicate samples were examined at intervals which were separated by other samplings or tests so that one cannot attribute this uniformity to a carry-over of ideas from one test to another. In the so-called grading or quality testing which was conducted, the graders were instructed to note any flavor that might be termed "raw" pea flavor and if this was objectionable, to lower the flavor rating for that sample. However, if the flavor was not objectionable the rating should not be affected. Few, if any, differences were noted between the various lots within one comparison group on the basis of averages. The only significant differences in averages were observed in the tenderness ratings. These, however, followed the changes in maturity or tenderometer grading of the particular sample and reflected the accuracy of the graders for picking out those particular points.

Canned samples from two previously reported studies *(7, 13)* were included in this quality examination. One series of such samples represented a test wherein rather extreme variations in blanching times were employed. It was expected that such variations might produce significant differences in flavor. However, on rather extensive testing by the panel of graders employed in this work, it was concluded that no significant differences could be detected in even the most extreme blanching conditions. The significance of this observation will be appreciated when the reader is reminded that proponents of short-time, high-temperature blanching techniques are told that such methods will result in poor quality products. The results of the tests described herein do not support such a belief.

Conclusions and Summary

Blanching studies with Sweet variety peas have been described with particular emphasis on certain nutritive factors. The work was conducted with a small experimental blancher so arranged that commercially blanched peas of the same lot could be obtained as control samples. Quality factors as well as the content of the vitamins, ascorbic acid and thiamine, were measured. Results of ascorbic acid assays demonstrated that short-time, high-temperature blanches effected the best retention of that vitamin, particularly with immature peas. With low-temperature, short-time blanches good retentions of ascorbic acid were usually observed, but these were nullified in subsequent steps of the canning operation. Thiamine retentions were slightly better in short-time, high-temperature blanches although the differences could not be called significant. Tests on the quality factors tenderness, flavor, and color of brine and solids in the canned product emphasized the observation that differences between commercial controls and experimental samples could not be detected.

The results of this study serve to emphasize the conclusion that enhanced nutritive value can be accomplished during the canning of peas with no sacrifice in quality by the use of high-temperature, short-time water blanching procedures. These observations are consistent with the findings observed by other workers *(7, 12)* who varied the time and temperature blanching relationship on commercial hot water blanchers for peas and reported similar benefits.

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Mr. N. H. Coonen, Research Department, American Can Company,
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Industrial and Legal Viewpoints

Food Products Liability[a]

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Past and present trends in Food Products Liability Cases are outlined and attention is called to certain hazards to packers and handlers of food products, in relation to suits for real and imagined damages.

The evolution of the law of food products liability in the various states is an example of legislation influenced by the trend of the times, and the so-called demand for social justice. Regulatory activities of such groups as the Food & Drug Administration, the Bureau of Animal Industry, and the various State and Municipal agencies, have been supplemented by statutory provisions. These, in turn, have been the subject of judicial interpretation to the point where the distinction between the functions of the legislative and judicial branches of our government has all but disappeared.

The late Justice Cardoza conceded that under our system of jurisprudence judges have, and in some cases should exercise, the right to make new law through what actually amounts to judicial legislation. This, he cautioned, merely means they have the right to legislate between gaps. They have the power, though not the right, to ignore the mandate of a statute, and render judgment in spite of it. Nonetheless, by that abuse of power, they violate the law *(1)*. The demands of social justice furnish no excuse for a violation of law. The opportunity to lay stumbling blocks in the path of sound judicial reasoning, and to open a fertile field for planting false or exaggerated claims, has been made possible by our appellate courts in ignoring the clear mandate of a statute. The heavy burden thus imposed upon those engaged in the food industry is worthy of careful consideration.

I am in no way connected with the regulatory activities or problems arising from Federal, State or Municipal agencies. My long association with the food industry has been in respect to its problems with the ultimate consumer.

In 1872 when California adopted its first Civil Code, specific provision was made for implied warranties of soundness and wholesomeness to arise on sales of provisions. The section read:

> "One who makes a business of selling provisions for domestic use warrants by a sale thereof, to one who buys for actual consumption, that they are sound and wholesome."

The law as thus established was merely a codification of the common law rule that dealers are deemed as a matter of law to warrant foodstuffs sold for immediate domestic use to be wholesome and fit to eat. Only two cases were reported in the fifty-nine years this code section was in effect.

Privity of contract was, of course, essential to the existence of all warranties, and the English courts, after which this act was patterned *(2)* have not seen fit to

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depart from this rule, in order to confer a right of action upon a remote purchaser.

The doctrine that a manufacturer of an article inherently dangerous to human life could be sued for negligence by a remote purchaser was first adopted by a Court in the United States in 1852 *(3)*. This was in the State of New York. In a comparatively short time it was held that this doctrine did not apply to manufacturers of food stuffs *(4)*.

A minority of jurisdictions permitted suit against a manufacturer of foodstuffs for breach of an implied warranty, even though it be instituted by one not a party to the sale. In the majority rule jurisdictions it was pointed out that all warranties are incidents of the law of sales and cannot properly be attributed to a manufacturer who has never had any contractural relationship with the person claiming the benefit of the warranty *(5)*. The suggestion that warranties on the sale of chattels should run with the article sold was dismissed as wholly contrary to all established doctrines of the law, and the opinions give little space to arguments that there may be an implied warranty for the benefit of a third party *(6)*.

The Uniform Sales Act of California was modeled closely upon the Sales Act of states applying the then majority rule. When this Act was adopted in 1931, Section 1739 of the Civil Code provided in part (and still provides):

"Implied Warranties of Quality. Subject to the provisions of this act and of any statute in that behalf, there is no implied warranty or condition as to the quality or fitness for any particular purpose of goods supplied under a contract to sell or a sale except as follows:

"(1) Where the buyer, expressly or by implication, makes known to the seller the particular purpose for which the goods are required, and it appears that the buyer relied on the seller's skill or judgment (whether he be the grower or the manufacturer or not), there is an implied warranty that the goods shall be reasonably fit for such purpose.

"(2) Where the goods are bought by description from a seller who deals in goods of that description (whether he be the grower or manufacturer or not), there is an implied warranty that the goods shall be of merchantable quality. . . ."

It would appear elementary that the statutory warranty arises only as between a "buyer" and a "seller." That is the clear mandate of the statute. There are no gaps that would justify judicial legislation. The first case decided by the Appellate Court subsequent to the passage of the Act applied this principle of law *(7)*.

This Act opened the door to the "Land of Opportunity." It was "open season" on the purveyor of foodstuffs. In a race to reap the benefits, a patron sued the operator of a restaurant for personal injuries resulting from the swallowing of a fragment of chicken bone contained in a chicken pie *(8)*. It was there, for the first time in California, held that the transaction between a restaurant keeper and a guest constituted a sale to which an implied warranty attached. The court said the application of the rule might impose a heavy burden upon the keeper of restaurants, but that consideration of public policy and public health and safety is of such importance as to demand that such obligation be imposed. We thus find judicial legislation enacted in the interest of social justice.

The Appellate Court denied the claim, it is true, but pointedly suggested that this was the sale of a chicken pie, and since chicken bones are not "foreign" to the particular dish, there was no evidence that it was not fit for human consumption. Furthermore, the Court, obligingly for those who seek fertile fields, pointed out that "the slightest deviation from perfection may result in the failure of the food to be reasonably fit for human consumption," "such as"—said this obliging court—"for example, glass, stones, wires or nails in the food served, or tainted, decayed, diseased or infected meats or vegetables."

That was the "Open Sesame!" Restaurant keepers were faced with every conceivable type of lawsuit. One plaintiff, perhaps with that very decision in hand, claimed that he had swallowed a turkey bone. But, alleged the plaintiff, the bone he swallowed was in the turkey *dressing*, not in the turkey, and a turkey bone in "dressing" was a "foreign substance" *(9)*. It was an auspicious opening of the "hunting season."

Then came a veritable avalanche of "glass cases!" *(10)*. There was glass in malted milk, glass in pancakes, glass in sugar, glass everywhere—except on the outside of a drink. No one ever mentioned the latter. "Social justice" was not interested in a container without flaws.

There are no cases more difficult to defend. A claimant makes the bald statement that she felt some glass in her mouth, that thereafter there was a hemorrhaging of the bowels, and complaints of internal disorders covering a wide range. The fact that there were no witnesses to the occurrence or the alleged hemorrhaging will not defeat the claim. A doctor is called. There is no evidence of any abrasion around the mouth or throat, and X-rays of the internal organs are negative for foreign substance. This is not conclusive. Glass will not show under an X-ray unless it contains a certain percentage of lead. The doctor's findings, as to objective symptoms, are entirely negative. A long hypothetical question is then propounded to the doctor. It is based entirely upon the subjective symptoms of the claimant. He states that in his opinion the claimant swallowed certain particles of glass, and is suffering as a result therefrom. We thus have the entire case predicated upon the uncorroborated testimony of the plaintiff. But that is sufficient to create a question for the determination of a jury.

Medical Science has proved that the ingestion of glass seldom causes injury. Any foreign substance entering the system is coated by nature in such a way as to facilitate its passage through the intestines. If it is sufficiently sharp to penetrate the wall of the intestines, peritonitis will immediately set in. If it attaches to the wall of the intestines, nature will continue to add to this coating and an irregular contour at this point will be revealed by X-ray. In the absence of objective findings there can be no major damage.

This is entirely logical. But logic does not always guide a jury in its deliberations. Many of us were taught that in ancient times ground glass was used as a subtle means of disposing of an undesirable. It is surprising how many jurors adopt this fallacious theory

in opposition to the testimony of outstanding medical authorities.

Several years ago I defended an action that was so fantastic it must have had for its origin some fable of ancient history. A woman claimed she found some small particles of glass in a malted milk. She rushed to a doctor, who made an examination of her mouth and throat. He found no abrasions of any kind, but prescribed a diet of roughage. She went home to bed, and remained in bed continuously thereafter. She was brought into court, more than three years later, on a stretcher accompanied by attendants who would periodically revive her with oxygen. There was no history of internal hemorrhage. There were no objective findings. She gave a history of grating pain, as if glass was cutting her every time she so much as drank a glass of water. The head-board of her bed was brought in. It had actually been worn from contact with her head when, she said, she had this excruciating pain that caused her to stiffen and rub her head against the head-board. Furthermore, she produced a bottle containing many particles of what she insisted was glass. These particles, she said, would come out of the ends of her fingers, her cheeks, her forehead, and various portions of her body, after gradually working up through the skin. Half a dozen medical experts testified that this was anatomically impossible. The particles were analyzed and found to be rock and sand. Her symptoms were those of an epileptic, and hospital records and those of prior attending physicians revealed a history of epilepsy dating back more than twenty years. In these reports were found the identical complaints of pain she later attributed to the ingestion of glass. The jury brought in a verdict in her favor for $12,500.00.

When the novelty of glass cases wore off, and we had been able to discourage some of the plaintiffs by way of defense verdicts, the minds of claimants turned to food poisoning. This was more difficult, because of the law requiring doctors to immediately make a report of any diagnosis of food poisoning. Doctors who had testified as to the dire results of cases of food poisoning were greatly embarrassed by questions as to why they had failed to report the diagnosis as required by law. The volume of these cases dropped off considerably, but they are still a matter of concern.

A certain radio and film comedienne approached the problem from a different angle. She sued a drug store for $100,000.00. It seemed that this young lady had a stomach-ache. Her doctor gave her a prescription. The prescription directed that she take one-half ounce, or one tablespoonful, every three hours. The prescription was filled at 5 o'clock one afternoon. After taking three doses of it, it was discovered that the druggist had misread the prescription to the extent that he had typed on the label "½ teaspoon every three hours" instead of "1 tablespoonful every three hours." This, said the young lady in her complaint, "caused plaintiff's condition to become worse, aggravated, and plaintiff became and remained seriously ill as a result thereof and/or as a result of the lack of proper medication as called for in the prescription; that as a result thereof plaintiff's condition became progressively worse, resulting in a physical collapse of plaintiff while engaged in the making of a motion picture upon a set therefor at and in the studios of R. K. O.; that after said collapse, plaintiff was confined to her home and bed for approximately a week thereafter and was thereafter recurrently confined to her home and bed and was caused to suffer great bodily pain, anguish and discomfort, all to her damage in the sum of $100,000.00."

I waited until I knew she was in the middle of the making of a big picture. I then had her served with a subpoena to appear in my office for the purpose of taking her deposition. The shoe was then on the other foot. We settled the $100,000.00 case for $100.00. The prescription? It was "4 ounces milk of magnesia, and 1½ ounces Paregoric!" We had no further claims from this particular party.

A Mexican claimant filed suit because he found a cockroach in the sauce served with a fish order. It lacked some of its legs, and plaintiff was quite certain he had eaten the legs. But, we argued, we had eaten snails in France, birds' nest soup in China; squid in Japan; and we had seen the natives eat dog in the Philippines, and offered for sale in Mexico was a broiled insect looking very much like a cockroach. The memory of that with which cockroaches are generally associated from common experience naturally arouses a feeling of revulsion. But if maggots are not found exclusively on filthy, decomposed and putrid animal substance *(11)* then certainly the same can be said of cockroaches. And food infested thereby, in the absence of testimony to the contrary, could not be said to be unwholesome. In fact, where was there any testimony that a nice, tender, broiled cockroach was unwholesome? (I did not, however, offer to prove the point by demonstration).

Time marches on! And the ingenious mind keeps apace! It wasn't long until the Industry was faced with a new menace, i.e., fright. A Mexican claimant, while drinking a bottle of Coca-Cola, in which the defendant permitted a cleaning brush to remain, became "violently ill and was rendered sick, sore and disabled" *(12)*. He was unable to prove that there was anything unwholesome in the brush, or the beverage. But, this ingenious claimant said, he saw something in the bottle (a brush) which he "thought" to be a bug or a spider, and that he "got kind of nervous" thinking he had swallowed a part of "that dirty bug." Despite the fact that the liquid itself was wholesome, and despite the fact that the brush in the bottle looked like a brush, the Court held that plaintiff's "idea" that it was a disgusting looking object which gave him a nervous shock constituted a violation of an implied warranty, and justified a judgment in his favor for $500.00.

News travels fast in the "Land of the Opportunist." Within a short time I was called upon to defend a case wherein the plaintiff suffered "grievous mental shock" by reason of being served a plate of soup containing two dead flies, to his "damage in the sum of $2,000.00." At the trial, the plaintiff, in considerable detail, recounted his horror at the sight of these two flies. Horrible! He had never seen a fly in his home. But as a part of the corpus delicti, he reached into his pocket carefully, unfolded a paper napkin, and produced two

very dead flies. We examined them under a microscope. The plaintiff examined them. He insisted they were the identical flies, that he had fished them out of the soup and preserved them as evidence. Here was a brush case, with a new twist. In a friendly argument with a judge having a sense of humor *(13)* we suggested that a dead fly in a plate of soup was reasonably worth $10.00. The judge, however, observed that with the rising price of commodities, the price of dead flies had also increased. And the market price of dead flies in soup was then established as $25.00 per fly.

While all of this was transpiring, wholesalers, distributors, and manufacturers were going their various ways, seemingly oblivious to the problems with which the very existence of the retailer had been threatened. But on September 6, 1939, the Supreme Court of California rendered a decision that affects everyone connected with the Food Industry *(14)*. It declared that under the provision of the Uniform Sales Act, a warranty of fitness of foodstuffs for human consumption runs in favor of all ultimate consumers, irrespective of whether they are in privity of contract with the warrantor.

In this case the husband purchased from K's restaurant a ham and cheese sandwich in waxed paper, which he later delivered to his wife. The sandwich, in a sealed container, had been sold to K's restaurant by the Duchess Sandwich Company about an hour previously. The wife ate a portion of the sandwich and then discovered it was wormy. She claimed mental disturbances as a result thereof, and she and her husband sued both K's restaurant and Duchess Sandwich Company for breach of an implied warranty for fitness.

In connection with the necessity for privity of contract between plaintiffs and the Sandwich Company to give rise to an implied warranty, the Court took the position that, in the case of foodstuffs, there is an exception to the general rule that privity of contract is required to support a cause of action for breach of warranty. The Court admitted that the factor of public policy afforded a background for its decision, and declared that "the remedies of an injured consumer of unwholesome food ought not to be made to depend 'upon the intricacies of the law of sales,' and the warranty of the manufacturer to such consumer should not be made to rest solely on privity of contract."

This is a clear instance of judicial legislation influenced by "public policy." It is illogical to the point of absurdity. If the rights of the injured consumer are not dependent "upon the intricacies of the law of sales" he would have no cause of action whatsover. His right of action for breach of an implied warranty is statutory. The statute which gives him that right is the Uniform Sales Act of California. It is this identical "law of sales" which our Supreme Court has held may be disregarded in part. I reiterate, the distinction between the functions of the legislative and judicial branches of our government has all but disappeared.

The decision was at that time contrary to the great weight of authority under the Sales Act as applied elsewhere in the various states. It created an exception to the law of implied warranties which, since this decision, has now been extended to practically every manufactured article, under the category of "articles inherently dangerous to human life." Finally, it relies upon obvious fictions to distort the law of sales, in an attempt to conceal the fact that it is judicial legislation. Unfortunately, the trend throughout the various states is in this direction *(15)*. Fraud needs no more motivating influence.

An obscure individual may, by purchasing from a small neighborhood store an article in a sealed, glass container, set up a chain of events that will result in a lawsuit involving not only the storekeeper, but the person by whom it was delivered, the wholesaler, the distributor, the manufacturer, and all who furnished ingredients to the manufacturer. Legal expense, alone, is becoming a grave problem. The resultant effect upon the Food Industry as a whole is evident.

The answer lies in the re-doubling of your efforts in the matter of "Sanitation in the Food Industry."

CASES CITED

1. "The Nature of the Judicial Process," by Justice Cardoza.
2. "Sale of Goods Act" (1893).
3. Thomas v. Winchester, 6 N. Y. 397.
4. Bishop v. Weber (1885) 1 N. E. 154.
5. Connecticut Pie Co. v. Lynch 57 Fed. (2) 447.
6. Giminez v. Great Atlantic & Pacific Tea Co. 191 N. E. 27.
7. Binon v. Sazaki, 5 Cal. App. (2) 15.
8. Mix v. Ingersoll Candy Co. 6 Cal. (2) 674.
9. Silva v. Woolworth Co. 28 Cal. App. (2) 649.
10. Goetten v. Owl Drug Co. 6 Cal. (2) 683.
11. Reese v. Smith, 9 Cal. (2) 324.
12. Medeiros v. Coca-Cola Bottling Co. 57 Cal. App. (2) 707.
13. Judge Thurlow Taft.
14. Klein v. Duchess Sandwich Co. Ltd. 14 Cal. (2) 272.
15. The exceptions being Florida, Georgia, Kansas, Louisiana, Mississippi, Missouri, New Mexico, North Carolina, Oklahoma, South Carolina, Texas, Virginia, and West Virginia.

Notes and Letters

We publish, herewith, two letters which conclude a discussion of methods applied to the estimation of *Salmonella* in dried egg products. We have followed this exchange of views with great interest and are happy that this section has provided an opportunity for frank discussion and clarification of details impossible in original papers without rendering them unduly cumbersome.

It is our wish that this will have pointed the way to others who may have questions of equal interest to our readers. This section is for your use, and we are most happy when you use it.

THE EDITOR.

THAT I BE FULLY UNDERSTOOD . . .

In the November, 1949, issue of FOOD TECHNOLOGY Mr. N. E. Gibbons takes issue with the simplicity of the